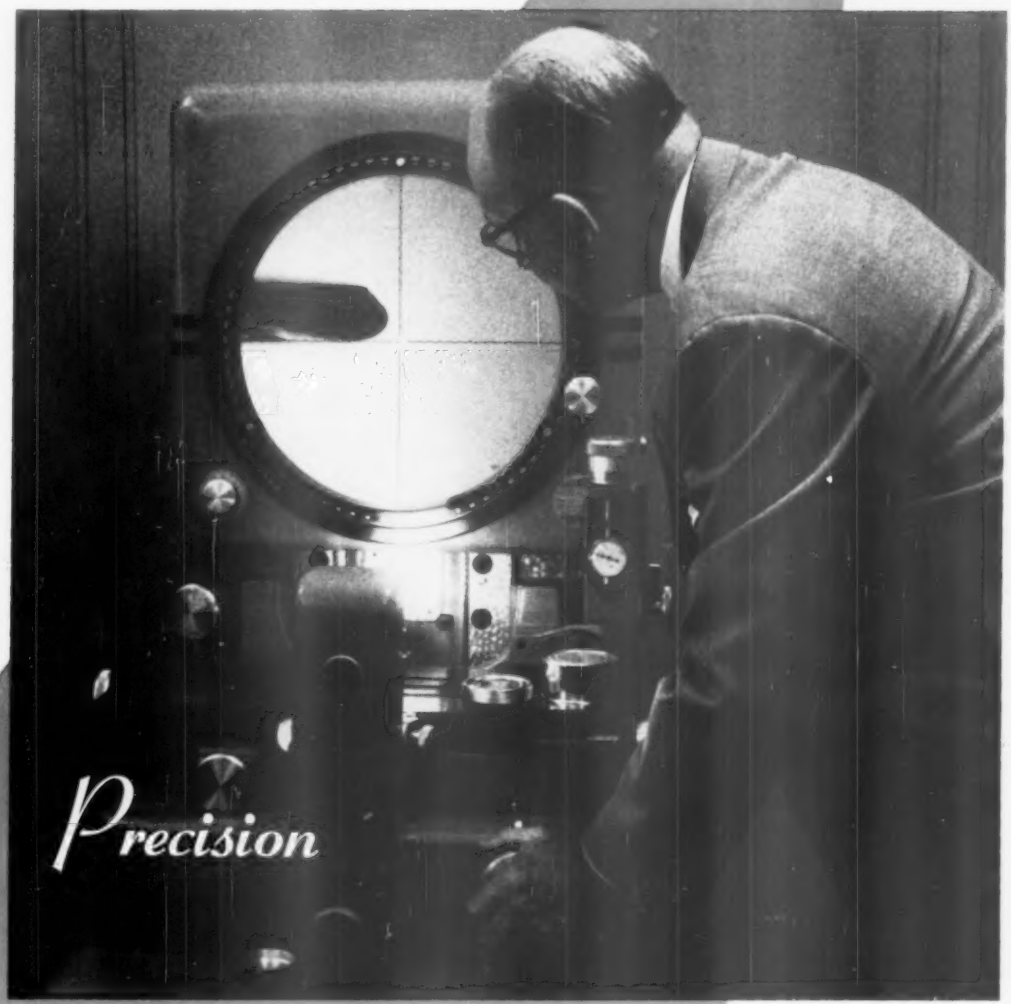
MARCH, 1959
Vol. 13, No. 3

FT food technology



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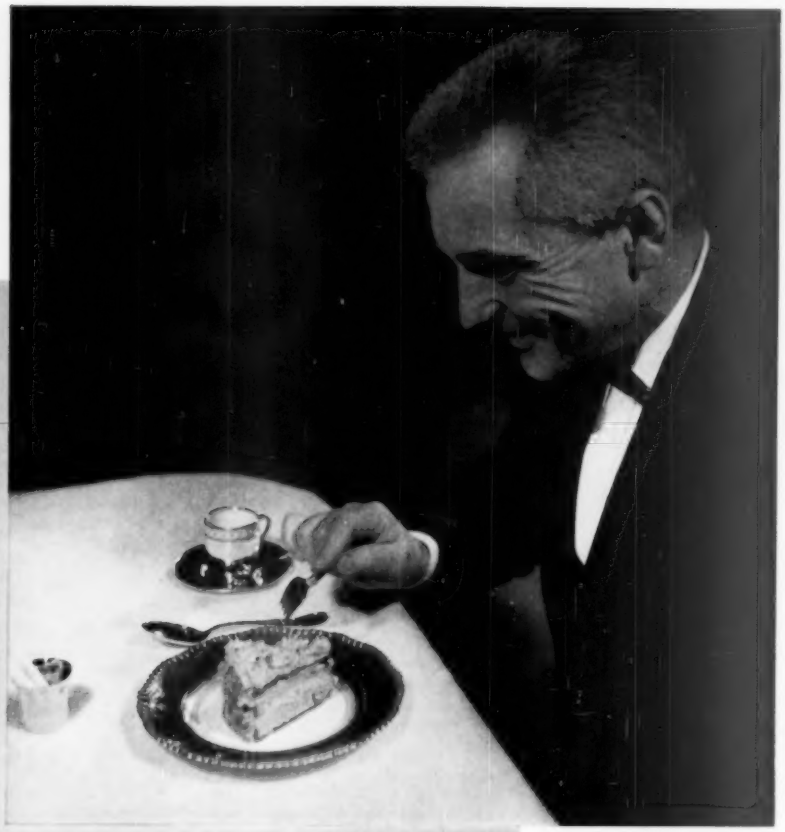

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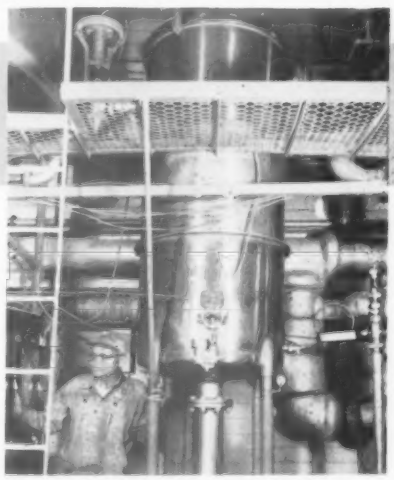

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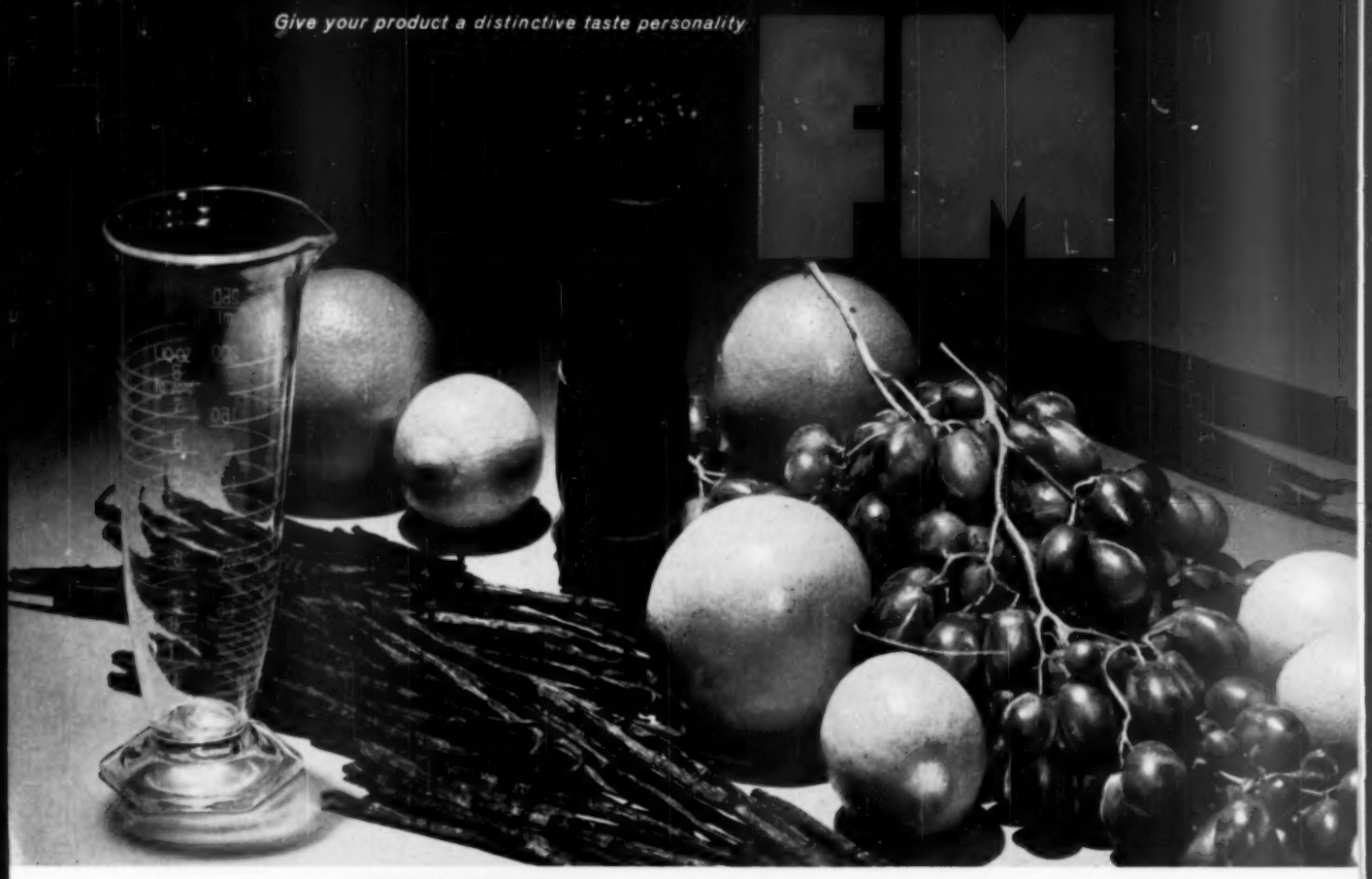

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IN THIS ISSUE—

THE TECHNICAL ARTICLES IN BRIEF

Flavor evaluation *Citrus concentrates*

Comparison of flavor evaluation methods for frozen citrus concentrates. Mardell D. Tompkins and G. B. Pratt.

Possibility of taste fatigue interfering with accurate flavor evaluation of citrus juices has long been recognized. Various procedures have been tried to avoid the so-called "taste saturation" effect of the essential oils present. The work here reported consists of a comparison of some taste test methods employed to establish flavor differences among 7 experimental variables of frozen concentrated orange juice. It is indicated that using the incomplete latin square design for tasting 3 samples at a time does not particularly improve the reproducibility of results over tasting all 7 samples at each session. The "ranking" method and the "quality rating" method gave results which were as accurate as those of the "hedonic rating" scale. Results of all the methods were consistent, although in some cases greater discrimination by the tasters was observed. Factors which appear more important in selecting a taste test method than mathematical efficiency are discussed. An evaluation was also made of the influence of juice temperature (refrigerated or room) on the panel judge's ability to discriminate between variables. (See page 149).

Microbiology *Commercially processed fryers*

Influence of acronizing on organisms causing spoilage in commercially-processed fryers. Kenneth Simpson, Charles W. Nagel, Henry Ng, R. H. Vaughn, and G. F. Stewart.

Thirty-six fryers representing commercially processed birds from California, Georgia and Alabama, with and without Acronize treatment, were obtained from several retail stores in the Sacramento, California area. After storage for 7 days at 40° F. the birds were examined microbiologically. All birds were found to have very high bacteria counts; yeast counts were generally quite low and in no case did they approach the bacteria counts. It is concluded that spoilage in commercially processed fryers may generally be attributed to bacterial rather than yeast growth, whether or not the birds are Acronized. (See page 153).

Tenderness measurement *Beef*

Tenderness of beef muscle as measured by pressure. Doris D. Sperring, William T. Platt, Richard L. Hiner.

Since one of the desirable qualities in beef is tenderness, an objective method of measure was sought. Two major factors were considered: (1) the mechanism should be adaptable to either cooked or raw samples; (2) the mechanism should give accurate results on a small, biopsy specimen. With an apparatus meeting these qualifications, studies on raw and heated meats and correlations with scores of the organoleptic panel could be made. A biopsy specimen would measure tenderness in the live animal and permit selective breeding. Pressure, either hydraulic or gas, to force the meat specimen through a small orifice was selected. The hydraulic pressure was more feasible. The devised tenderness press, a mechanized modification of the Carver juice press, was found to be the best means of measuring raw biopsy specimens. Data from the press correlate tenderness of heated and raw specimens with scores of an organoleptic panel. The pressure (measured in pounds) as applied to a small core of meat is recorded at the time of the first extrusion. Preliminary tests of the apparatus on homogenous substances gave reproducible results. Three major raw muscles *Longissimus dorsi*, *Semitendinosus*, and *Psoas* were tested from each animal. The *Longissimus dorsi* muscles were also tested after heating by the new apparatus, the Warner-Bratzler Shear, and an organoleptic panel. Ninety-two animals were used in the experiment. Highly significant differences were shown between raw and heated samples and among the raw muscles. There was a highly significant correlation of tenderness press data with the scores of the palatability group. (See page 155).

Radiation *Potato tubers*

Storage rot susceptibility of potato tubers exposed to minimum sprout inhibiting levels of ionizing irradiation. D. T. Duncan, W. J. Hooker, and Fred Heiligman.

Storage rot incidence of potato tubers following exposure to radiation was determined with relatively large lots of tubers at low levels (2.5 to 15.0 kilorep) of intensity. Nonwounded, noninoculated tubers developed little storage rot at these levels of radiation. At the 10-15 kilorep intensities sprouting was inhibited. Wounding of tubers before or after radiation increased incidence of rot over nonwounded tubers. Incidence of storage rot in wounded, noninoculated tubers was highest at the high levels of irradiation intensity. Inoculation with either *Fusarium sambucinum* Fuck. form 6 Wr. or *Erwinia carotovora* (L. R. Jones) Holland increased incidence of rot. Rot incidence of wounded, inoculated tubers was progressively increased as radiation intensity was increased. At these low levels of radiation, rate of rot progression through tuber tissue could not be correlated with radiation intensity. Rot following inoculation with *F. sambucinum* f. 6 was consistently more severe when inoculation followed irradiation than when inoculation preceded irradiation. A similar but less distinct trend was obtained with *E. carotovora*. Indiana grown Sebago tubers developed consistently more rot when wounded or when wounded and inoculated after radiation than when

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wounded before irradiation. With the other tuber lots there was no consistent relationship between rot incidence and time of wounding. (See page 159).

Packaging *Frozen ground pork and beef*

Effect of packaging on palatability and weight loss of frozen ground pork and beef. J. D. Winter and Shirley Trantanella.

Ground pork and beef were packaged, frozen, and stored at 8° to 12° F. (−13.33° to −11.11° C.) for periods up to 11 months. Packaging materials used were polyethylene film of different gauges, polyethylene coated cellophane, laminated polyethylene-cellophane, polyethylene coated aluminum foil, polyethylene coated with polyvinyl alcohol, aluminum locker foil, and polyethylene film treated with antioxidants. Some lots were packaged in an initial atmosphere of nitrogen. All lots were judged for palatability and a statistical analysis was made. Palatability scores for pork at the 4-month storage period indicated that the palatability of all samples remained good during this period regardless of packaging material or treatment. Beef was not judged at this period. *No advantage was indicated by packaging in an initial atmosphere of nitrogen with the plastic films used in this study.* There were no significant differences in palatability attributable to treatment of the packaging materials with antioxidants at the concentrations used. Significantly higher palatability scores were found for pork stored 7 months in the heavier gauges of polyethylene than in the lighter gauges. Significantly higher scores also were found for pork stored 7 months in films made of polyethylene in combination with other materials than in films made of polyethylene alone. In both instances differences in scores were not large. *No appreciable change in weight occurred in any of the lots during storage.* Since the storage temperature was considerably above those normally used, no conclusions regarding storage life of the product at recommended temperatures should be inferred. (See page 165).

Color standards *Wine*

Color values of California wines. M. A. Amerine and C. B. Bailey.

No color standards are presently available for use by the wine industry in standardizing the color of commercial samples of California wines. Eighteen California white and 13 red wines were ranked as to commercial acceptability in their appropriate types by two experienced wine experts. These were then visually classified by the Munsell system and against white and red color standards. Absorption curves were obtained from 370 to 700 mμ and at every 10 mμ. From these data the trichromatic coefficients were obtained and from them the color characteristics: hue (dominant wavelength), lightness (or brightness), and purity; ranges of acceptable values for the various types of wine are suggested. Difficulties of defining wine type colors because of the very wide range in colors from very light yellow to dark red are emphasized. (See page 170).

Military feeding *Applicability of new processing methods*

An appraisal of new processing methods for military foods. L. E. Clifcorn.

Criteria for military foods are a high order of acceptability, space and weight saving, storage stability and ease of preparation under the conditions of their intended use. Since World War II many advances have been made in the acceptability and storage stability of dehydrated foods. With present concepts of military logistics this class of foods meets the necessary criteria best if a high order of acceptability can be attained. Most canned foods are acceptable for military base use with the exception of the canned meat items where improved palatability is demanded. New processing techniques have not been able to solve this problem, although product formulation has contributed considerably. Although high temperature short time processing can offer improvement in quality and nutritive value to many canned food items, aside from canned fluid milk significant potential for advance is not apparent. Dehydrocanning has definite possibilities. Irradiation treatment of meats has potential. Combination treatments of irradiation with heat, dehydration, refrigeration or antibiotics have broad horizons. It is imperative in evaluating new processing methods to select the specific food products for which each can make a significant improvement, by the criteria mentioned, over what is produced today by conventional processing methods. (See page 176).

Sanitation *Chlorine dioxide*

Use of chlorine dioxide for cannery sanitation and water conservation. John L. Welch and John F. Folinazzo.

Water acquisition and disposal problems encourage food processors to conserve water. Vegetable canneries have developed systems to reuse factory water. This reuse of water, while conserving water, increases sanitation problems. In-plant chlorination and rechlorination of water to be reused have helped considerably in maintaining sanitary conditions. Rechlorination of used cannery water, however, is not always feasible due to unfavorable reation of chlorine with dissolved components of used water. Chlorine dioxide is a more powerful oxidizing agent than chlorine. Chlorine dioxide treatment of used water during pea and corn canning operations is described. Total bacteria counts on product and in water and visual observation of equipment were used as indices of santitary condition. A statistical study of the data indicates that treatment of used water with chlorine dioxide in the cannery in question was more effective in maintaining sanitary conditions than in-plant chlorination alone or in-plant chlorination plus rechlorination of used water. Because of this, water which formerly was considered unsatisfactory for reuse could be used again at points in the factory previously requiring fresh water. (See page 179).

Texture evaluation *Potato tubers*

Relation of chemical composition and some physical properties to potato texture. Gerald Kuhn, N. W. Desrosier, and Gale Ammerman.

Relation of 6 potato textures and specific gravities, conductivities, moisture contents, chlorine contents, and rela-

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tive viscosities was analyzed. Data indicated that differences in texture scores were due to varietal characteristics; texture scores were highly related to specific gravity. There was little relation between electrical conductivity values and texture scores, but the percent moisture gain during cooking was highly related to texture. Tubers of higher starch content absorbed more water upon cooking yet possessed a dry mealy texture. Chlorine content was directly related to texture as evidenced by the correlation coefficient which approached significance. Maximum relative viscosities were related to texture scores but more highly related to specific gravity. (See page 183).

Economic analysis *Processing of apple slices*

Trimming time and yield factors in processing of apple slices. Anthony Lopez, Charles B. Wood, Joseph M. Johnson.

Factors which affect time and recovery of various fractions in the peeling and trimming operations during manufacture of canned and of frozen apple slices were evaluated. Interrelationships between the peeling and trimming operations were studied. No significant differences were found among 4 varieties of apples for yield of slices, screenings, peel and core waste, or trim waste for fruit of the same grade and size. In all instances size had a significant effect on yield of slices and on percent screenings. Although there was a significant effect of size on peel and core waste between the smallest and the largest size class, there was not a significant difference between the small and medium or medium and large size classes when plant differences were taken into account. Effect of size on total trim waste was not significant. Grade had a significant effect on yield of slices and on defect trim but not on peel trim or on screenings. Trimming time increased as size decreased and as total trim increased. Variations in peels and cores and in total trim waste were the greatest cause for variations in yield of product. Because of the relationship of size of apples with both peel and core waste and total trim waste, size was a more important factor affecting yield than grade. Variations in grade and in size have about equal effect on trimming time. One per cent increase in defect trim resulted in approximately 1.7 minutes increase in trimming time for 100 lbs. of apples of any size. The estimating equations developed from methods used in Experiment II of this study may be used in plants which process apple slices for determining differential costs of peeling and trimming apples of different size and quality. (See page 186).

Packaging *Prepackaged meat*

Factors affecting quality of prepackaged meat V. Broad comparisons of variables and quality attributes. C. Olin Ball.

Variables and attributes compared are: bacterial count, color, flavor, cooked odor, organoleptic quality, and vacuum after storage. Purpose of the article is to place the findings of this series in perspective. The package types used in the investigation included cans, vinylidene, copolymer, coated cellophanes, cellulose acetate, polyethylene, three laminates, and trithene. All flexible containers used in the study were 5 x 6 in. pouches, sealed, except in special instances, under 27 to 29 in. vacuum. (See page 193).

Flavor evaluation *Chicken muscle*

Some factors affecting intensity of flavor in chicken muscle. D. W. Peterson, Marion Simone, A. L. Lilyblade and Ruth Martin.

Evaluation of flavor of chicken dark muscle (leg and thigh) and light muscle (breast) from birds under several physiological conditions was made by use of paired sample tests on broths prepared from the muscle. *Age.* Dark muscle of 19-month-old hens had a more intense flavor than dark muscle of 3-month-old pullets. Dark muscle of the older birds had a more intense flavor than breast muscle of the same birds. No differences were found between light muscle of younger and older birds or between dark and light muscle of younger birds. *Sex hormones and exercise.* Groups of young birds were given the following treatments for periods of approximately 8 weeks before they were slaughtered at the age of 3 months: stilbesterol or testosterone implantation; intensive exercise at hourly intervals for 10 hours each day. Stilbesterol or exercise decreased the flavor intensity of breast muscle but had no effect on dark muscle. Testosterone was without effect on flavor of either type of muscle. The relationship of flavor intensity to some chemical fractions of muscle is presented. (See page 204).

Storage study *Canning quality of cling peaches*

The effect of cold and modified atmosphere storage on the canning quality of cling peaches. L. L. Claypool and L. D. Davis.

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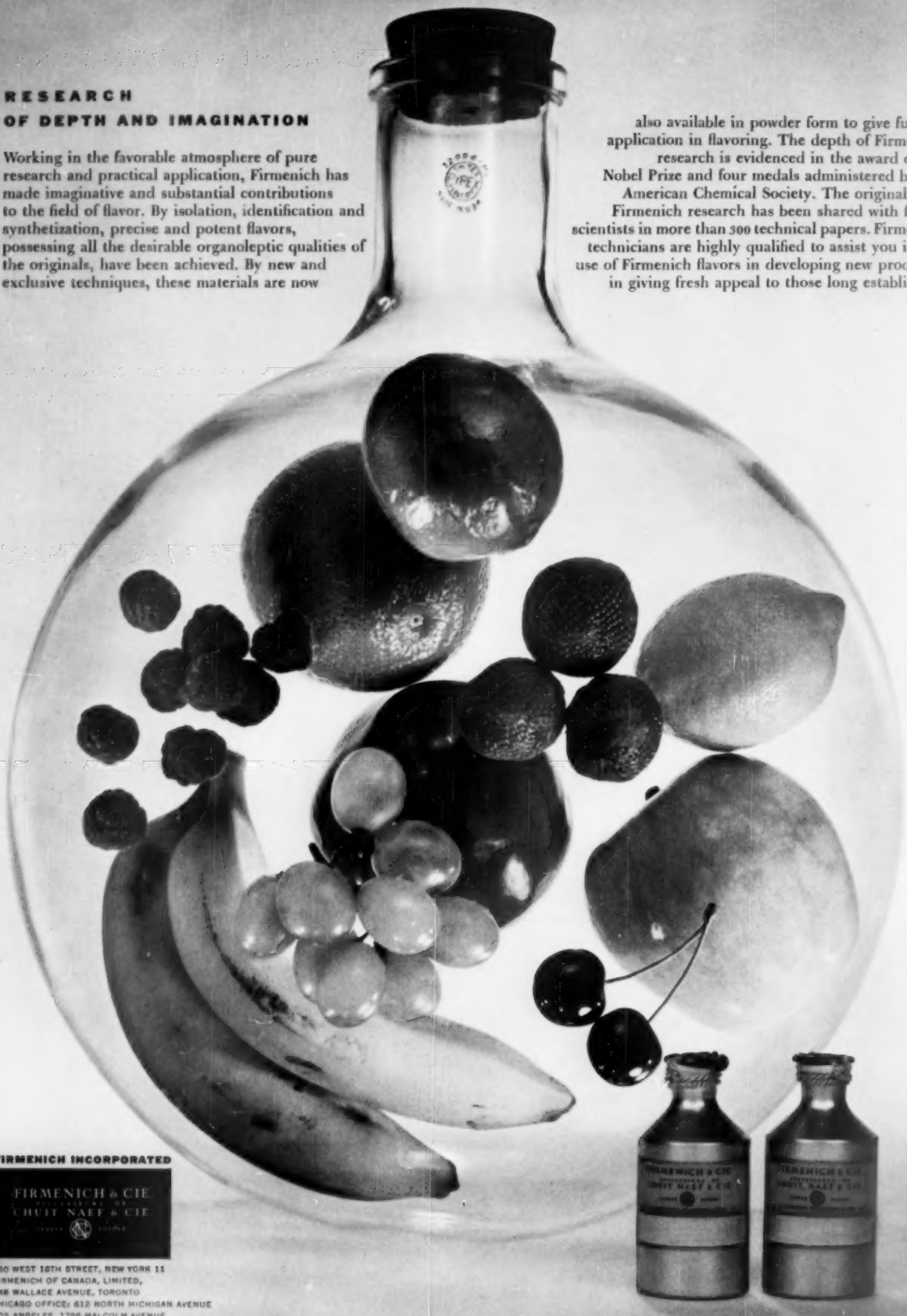

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Five varieties of cling peaches were harvested at 2 maturities and stored in air at 3 temperatures for variable time intervals up to 30 days prior to canning. Peaches were held also in modified atmospheres enriched in carbon dioxide content, or greatly depleted in oxygen content. Test lots of canned fruit were rated for flavor and chemical determinations made of H^+ concentration and total acidity of the syrup. (See page 208).

New product *Potentials of carob*

Carob varieties and composition. R. J. Binder, J. E. Coit, K. T. Williams, and J. E. Brekke.

Thirty varieties of carob were analyzed for some nutritive factors in an effort to acquaint the food industry with these factors and to provide a preliminary survey of varieties that might be suitable for commercial cultivation in the United States The carob varieties analyzed contained extremely high amounts of sugar, mostly sucrose and invert sugars, compared to other fresh fruit tree crops in harvest-ripe condition. Protein and carbohydrate content of the pod flesh makes carob compare favorably with barley in nutritive value. Imported carob is currently manufactured in the United States into a flour for use as a food and in pharmaceuticals. When incorporated into confections such as cake, cookies, candy, and ice cream, the flour imparts a flavor closely resembling that of cocoa or chocolate. (See page 213).

Drying techniques *Pressure, temperature, time, etc.*

Drying techniques under high vacuum conditions. W. Conley, F. Fixari, and G. W. Bard.

Absolute drying pressure, drying temperature, source of heat, and drying time are easily manipulated to produce desirable heat transfer effects during the continuous vacuum dehydration of citrus and other food products. Effects of each of these and several important physical phenomena, such as puffing, are illustrated. Techniques of heat manipulation, such as radiant heat and steam conduction heat, puffing to create this expanded layer, and addition of drying aids to assist in creating this expansion, are discussed. The importance of keeping this expanded layer in the puffed condition during the entire drying cycle is emphasized. Consideration is also given to the general physical condition and properties of the material to be dried before processing, such as solids concentration, adhesiveness, invert sugars, and viscosity. Several important factors have been found which influence final product density such as initial feed solids concentration and drying temperatures at various stages of the drying cycle. Many of the process variables which occur before dehydration may be corrected in the Chain Belt dehydrator by the correct manipulation of temperature profiles, drying times, and drying pressures. General operation of a continuous vacuum dehydrator is described using a hypothetical product illustrating how the equipment is set into operation and finally under automatic control. Materials, easily dehydrated by this means, which have been proven in the laboratory and through commercial application are: coffee, orange, grapefruit, citrus Vitamin P, whole milk, soft drink bases, tomato, etc. (See page 217).

IFT NEWS

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1959	
March 31-April 2	Annual Meeting of the Research and Development Associates, Food and Container Institute, Inc., Statler Hotel, Washington, D. C.
April 2-4	The Refrigeration Research Foundation Annual Meeting, Statler Hotel, Washington, D. C.
April 5-10	135th National Meeting American Chemical Society, Boston, Massachusetts
April 20-22	American Oil Chemists Society Spring Meeting, Roosevelt Hotel, New Orleans, Louisiana
April 28-May 1	Annual Convention of the Institute of Food Technologists, Australia, Mayer Chalet, Warburton, Victoria
May 17–21	**Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadelphia, Pennsylvania**
June 7-11	76th Annual Convention of the National Confectioners Association, Conrad Hilton Hotel, Chicago
June 9-13	Second Inter-American Food Congress, Carillon Hotel, Miami Beach, Florida
June 10-12	Second International Symposium on Gas Chromatography, Kellogg Center, East Lansing, Michigan
June 11-12	Canadian Institute of Food Technology, 2nd National Conference, Royal Hotel, Toronto
1960	
May 15-19	**Twentieth Annual Meeting of the Institute of Food Technologists, Fairmont Hotel and Masonic Temple, San Francisco, California**
1961	
May 7-11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 17-20	**Twenty-second Annual Meeting of the Institute of Food Technologists, Amercana Hotel, Bal Harbor, Miami Beach, Florida**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

REGIONAL NEWS

MINNESOTA

"Wrapped up in the history of the world is food," said Mary H. Kimball, Home Service Center of Pillsbury Co., Minneapolis. She spoke to members and wives of the Minnesota section of the Institute of Food Technologists on January 21, 1959. Her talk, which covered 100 years in the food field, is herewith summarized.

GRANDMOTHER'S KITCHEN CUPBOARD

Mendelssohn's "Wedding March," and "Jingle Bells" were written in 1858, Miss Kimball remarked. And *Peterson's Magazine* and *Godey's Ladies Book* were timely sources of housekeeping advice and household hints.

Boiled isinglass. *Peterson's Magazine* had a cookbook section. One recipe for blanc mange called for a half-ounce of isinglass boiled for 15 minutes as a thickening agent. A large tablespoon, *Peterson's* food editor explained to her readers, was equal to 1 gill and 16 large tablespoons were equal to one pint. Knowledge of nutrition was elementary.

"There was no mention in any of these recipes of vegetables, fruits or salads," stated Miss Kimball.

From 400 B.C. until 1830 food was thought to contain one element to sustain life. In 1830 the startling discovery was made that food could be divided into three elements—carbohydrates, fats, and protein.

"By 1858 serious study of nutrition was only 24 years old, and so no wonder the fresh produce wasn't mentioned," Miss Kimball commented.

Food prices in 1858, as quoted by the home economist, were flour for $10 a barrel, butter at 34 cents a pound, potatoes at $1.25 a pound, pork for $30 a barrel, and coffee at 20 cents a pound.

Twenty-five years later, said Miss Kimball, the *Ladies Home Journal* was born (1883). "There is a Tavern in the Town" was the hit of the year and the Brooklyn Bridge was opened. Edison's incandescent bulb was 5 years old, but only 12 cities offered electric service to the public.

Oranges were considered a holiday fruit and no one knew anything about grapefruit. Molasses, vinegar, and kerosene stood side by side in the grocery store.

Cook-Chex takes the last trace of guesswork out of production control.

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There were no packages and no cans. Food advertising was in evidence, however, and General Mills and Pillsbury ads were to be noted in the magazines of the era.

Travelers' Soup. Travelers' soup was a recipe in one of the magazines of 75 years ago. It called for two rounds of beef, a whole ham, and two legs of veal. After the soup was simmered for several days, the juice was strained off, boiled to a thick syrup and dried in long trays. It became crisp and brittle and was then cracked up and put into small boxes. "The traveler had only to add water to these pieces to get a very nutritious soup, it said in the magazine," Miss Kimball reported.

You could also find ads for milk in glass jars, but the milkman came from door to door in that day and gave you the amount of milk you wanted in whatever container you provided for him.

By 1883 minerals had begun to enter the nutrition picture.

Moving along another 25 years, Miss Kimball told the group that "Shine on Harvest Moon" was the song hit, Orville Wright stayed up an hour and 14 minutes in his flying machine, and the Gibson Girl was the acme of American womanhood and beauty. The automobile was being regarded as something that was here to stay.

"We start now to find color in the *Ladies Home Journal*," said Miss Kimball. "And food advertisements were definitely on the increase with certain brands becoming more and more familiar—Baker's Chocolate, Campbell's Soup, Cream of Wheat, Pillsbury's Best flour, Washburn-Crosby's Gold Medal flour and the meat packers, Armour, Cudahy, Swift and Co."

Exit the wood and coal range

Mrs. Rorer was *the* food editor of the day, Miss Kimball reminded her audience. Mrs. Rorer found gas and oil stoves expensive to operate and did not recommend using them for baked beans, soups, or other dishes that require long cooking. But Mrs. Rorer was not one to obstruct progress. "The *modern* kitchen will have gas or oil, but wood and coal can be managed," wrote Mrs. Rorer, implying, possibly, that wood and coal were only for the old fogies.

Nutrition in the 1900's started including calories.

"Just 25 years ago," went on the speaker, " 'The Easter Parade' by Irving Berlin, 'Roberta', and 'Stormy Weather' were on everyone's lips. 'The romance of Helen Trent started on radio." Food prices were low but jobs were hard to come by.

Those depression days people liked to think and read how the other half lived. All of the food advertising seemed to run to pictures of famous chefs in famous hotel kitchens, famous movie stars and the dishes they liked best, dinners of famous hostesses, etc. You found recipes for Greta Garbo's omelet and Jackie Cooper's salad.

Food and nutrition knowledge had advanced to where vitamins as well as minerals were very well known. Food ads showed more and more color. There

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CERTIFIED FOOD *Colors*

Tempting, eye-appeal attains its most potent sales effectiveness with Red Seal Colors of unsurpassed brilliance, purity and uniformity. Let Warner-Jenkinson produce—and precisely re-produce—the exact colors to give your products the greatest possible taste-stimulating attractiveness.

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West Coast: 2515 Southwest Drive, Los Angeles 43, Calif. • Warehouses: Boston, Jersey City, Atlanta

were no signs of mixes, and pictures of cakes were small and flat by today's standards.

And cigarette ads showed prominent women smoking.

Four hours a day in the kitchen

Women of 1933 were spending 4 hours per day in their kitchens preparing food for four, whereas the average homemaker today is spending one hour and 36 minutes a day fixing food for four, said Miss Kimball. And she would like to spend less.

"The homemaker to us in the food industry is a little like the star of *Damn Yankee*. You know—"What Lola Wants Lola Gets," she said.

Miss Kimball concluded her speech by pointing out the convenience foods there are today and some of the experimentation in novel preservation methods, such as irradiation of food. The food industry and the food technologist is going to give Lola what Lola wants.

PHILADELPHIA

Dr. John Sharf, Research and Development Center, Armstrong Cork Company, was the speaker for the February meeting. His topic "Effects of Nuclear Explosion on Packaged Food and Beverages" was a fascinating report of his observations during the 1955 Continental A-Bomb tests. An extensive laboratory examination of the exposed products was made and the highlights of the findings plus on-the-scene color photographs furnished an impressive lesson in nuclear effects on material.

The Philadelphia Section has an active employment committee headed up by Dr. Walter Obold of Drexel Institute. Openings are announced for qualified meat technologists, beverage specialists, and flavor chemists.

Another service available to Philadelphia food researchers (through not confined to them) is a book and document finding service provided at a moderate annual subscription by the University of Pennsylvania (Room 219, Logan Hall, EVergreen 2-5104). The service covers the holdings of Philadelphia area libraries in industry, scientific, and historical fields (approximately 6 million volumes).

The Philadelphia Section, host of the Nineteenth Annual Meeting of the Institute of Food Technologists, May 17–21, 1959, looks forward to your visit in the spring.

N. CALIFORNIA

Review. During 1958 the Section held eight General Meetings. Six were dinner sessions in the immediate Bay Area, with prominent outside speakers on special subjects in Food Technology. A seventh meeting, held at Modesto on November 13, featured a panel discussion on Precooling and Cold Storage of Fruits and Vegetables for Processing. On December fourth the All-Day Meeting, with 24 papers, was held at the Western Regional Research Laboratory. The All-Day Meeting included 8 "General Papers" in the morning session, plus 5 papers on "Analytical Procedures" in one afternoon section and 11 "Specialized Papers" in the other afternoon section, plus the usual, evening, Social Banquet. Attendance at the monthly meetings was as follows: February, 172 persons; March, 103; April, 122; June, 92; August, 92; October, 131; November (at Modesto), 142; and December 4 (all day), approx. 230.

Membership Status. Membership figures covering the past 5 years are as follows:

Date	National members	National students (added to Nat'l)	Section members	Section students (add to section)
End '54	411*	....	488	17
End '55	374	....	499	30
End '56	....	....	530	20
End '57	453*	21	529	22
End '58	498	34	549	22

* Corrected to the National Card File by the Institute Office in Chicago.

Note that the figures given for National Members include all individuals who are members of the National Institute in the Section Area. The recent count of 498 Institute Members is split as:

Professional Members	346
Members	152

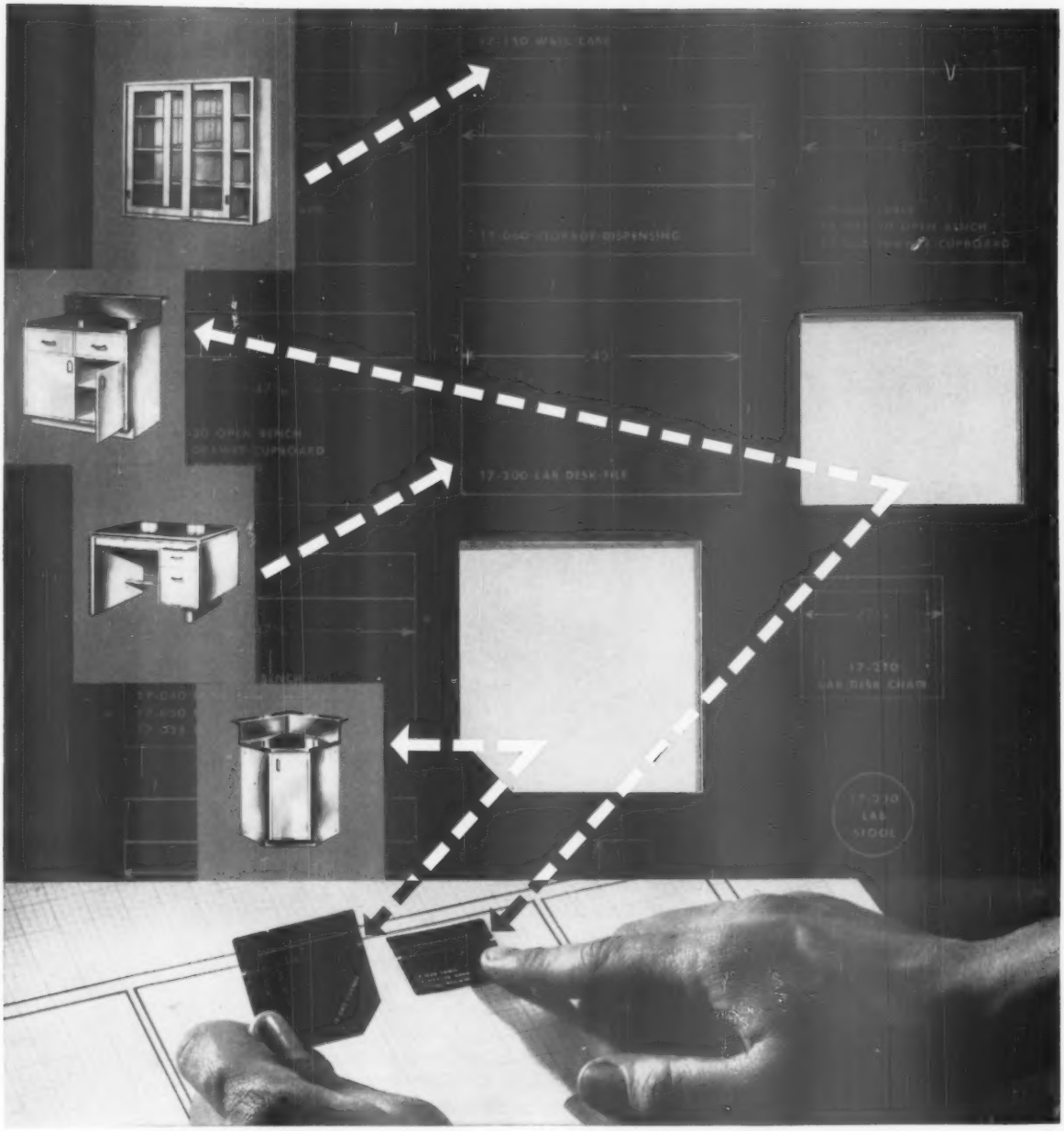
Special Social Functions. The Annual Picnic was held at the Redwood Regional Park on June 7, 1958. There was a Spring Golf Tournament at Castlewood Golf Course at which John Kilbuck won the trophy, followed by a Fall Golf Tournament at which E. R. MacGregor became the trophy holder.

Awards. The W. V. Cruess Award, with its financial stipend, went to Miss Joan Rae Clark, who is studying Food Technology at the University of California, Davis. The General Foods Fellowship was awarded to Mr. Harry Snyder, also in Food Technology at Davis. The Man of the Year Award was presented to Norman E. Liles.

Operating Costs. Expenses have been increasing over recent years so it became desirable to raise Section Dues to $3.00. A budget is being adapted as a basis for proposed cost accounting. *The Hornblower*, with Harold Adams as editor, has published six interesting and informative issues during 1958, but this publication is not fully supported by its advertising. The anticipated Directory Issue of the *Hornblower*, for 1959, is included in the new budget. Expansion of activities of an already active Employment Committee is being contemplated, and may involve substantial expenses. Fortunately, from the National Convention, to be held here in 1960, income is expected to considerably exceed expenditures.

The National Convention in 1960. Good progress can be reported on the 1960 National Convention to be held in San Francisco, with John Kilbuck and Bruno Filice acting as Convention Co-chairman. Committee Chairmen have been appointed. Space reservations have been made in the new Masonic Building and in the nearby Fairmount Hotel.

—*Myron J. Powers*



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BRITISH COLUMBIA

On Wednesday, January 7, 53 members and guests of the B. C. Food Technologists attended the first meeting of the 1959 season in the Home Economics Building at the University of British Columbia. Four speakers discussed various aspects of the Fishing Industry—from whaling to microbiology.

Whaling in British Columbia. Mr. Dave Barbour of Norman L. Armstrong Ltd. spoke on "Whaling in B. C.," and illustrated his talk with a series of beautiful color slides showing how the whale is taken, transported and processed. Although whaling began in B. C. before 1900, a period of rapid growth has occurred since 1948, with 754 whales of all types being taken in 1958. Canada is a member of the International Whaling Commission and the size and condition of the catch is governed by international agreement.

Fish Processing and Trends. The next speaker was Mr. Art Woodland, Plant Superintendent, Imperial Cannery, B. C. Packers Ltd., who spoke on "Fish Processing and Processing Trends." High speed machines and improved transport facilities have led to a marked reduction in the number of fish canning plants. For example, one company has reduced from thirty plants to three. Consolidation of plants appears to have reached a plateau over the past few years, but with the advent of automation, further consolidation is likely to take place.

Mr. Woodland felt that one of the most important recent developments has been the adoption of standards of identity through industry-government cooperative action. Looking to the future, there will be more automation and consolidation of plants; also more prepackaged and precooked products and the adoption of better product protection practices.

Transporting, Storing Fish in Refrigerated Sea Water. "Transport and Storage of Fish in Refrigerated Sea Water" was the topic of the next two speakers from the Pacific Fisheries Technological Station. Some of the engineering aspects were described by Mr. John Harrison, Mechanical Engineer. The idea started as a novelty but the results soon showed great promise, and a full scale trial was undertaken on the vessel "Silver Viking." Some of the details and problems encountered in fabricating and operating the system were described. For new installations, direct diesel drive and a central tube-type brine heat exchanger are being recommended.

Microbiological Aspects. Dr. N. Tomlinson discussed some microbiological aspects encountered in the use of refrigerated sea water. By adjusting the potassium content of the sea water, the leaching of potassium from the fish flesh during storage was oversome. The use of the antibiotics OTC and CTC in the sea water reduced bacterial counts significantly. Residues of the antibiotic in the flesh were found to be 99% destroyed by holding the fish flesh at 90° C. for five minutes. The brine pipelines necessary with the central heat exchanger pose another problem in sanitation, and work is now underway on this problem.

(Continued on page 19 following Technical Section)

Introduction

As part of a continuing study of the properties of distilled monoglycerides, it is of interest to know the solubility of water and water solutions in mixtures of oil and distilled monoglycerides.

This phenomenon has several interesting applications. It has been suggested, for example, that water-soluble dyes can be used to replace certain oil-soluble F.D.& C. colors by dissolving water solutions of the dyes in oil.

So . . . we tried it, and it works.

Conclusions

1. Fats and oils can be colored, using water-soluble dyes and a monoglyceride as a solubilizing agent.
2. Emulsions can be prepared from these oils and water which have an appearance quite similar to that obtained using oil-soluble dyes.
3. The amount of coloration obtainable by this technique is within a practical range.

We've been trying other things too—the solubilization of various inorganic ionic salts in oil, the dissolving of ascorbic acid, riboflavin, nicotinic acid, caffeine, quinine hydrochloride, and other such physiologically active materials. And we plan to try the solubilization in oils of such materials as sodium cyclamate, monosodium glutamate, amino acids, complexing agents, fungicides, and flavoring agents.

We're ready to talk now to processors who might improve their product or lower costs by incorporating water-soluble materials in oils or fats. And should the talks bear fruit, we have the capacity to ship *Myverol*® *Distilled Monoglycerides* by the tank car. ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York and Chicago • W. M. Gillies, Inc., West Coast • Charles Albert Smith Limited, Montreal and Toronto.

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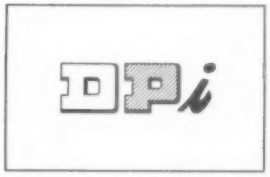

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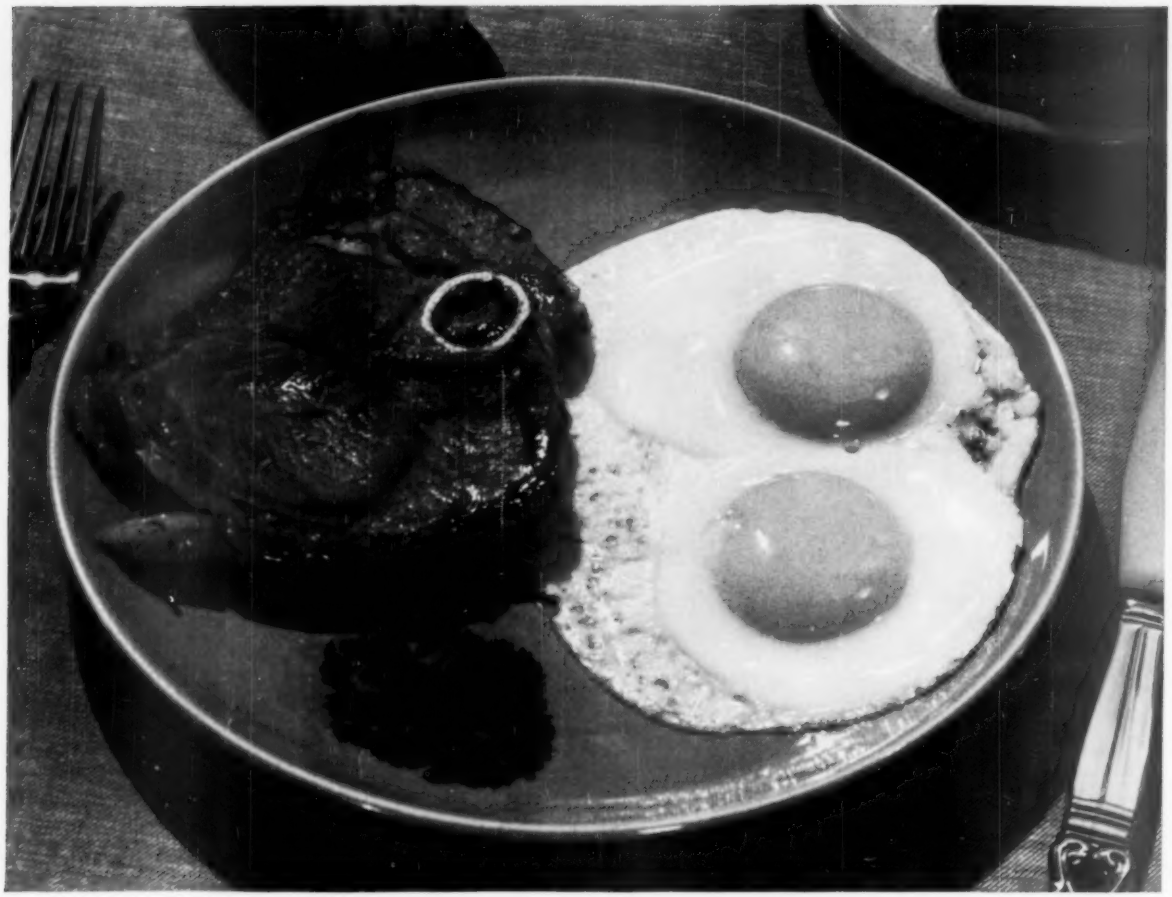

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The Curafos story is typical of the results achieved by Calgon's 25 years of research.

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Comparison of Flavor Evaluation Methods for Frozen Citrus Concentrate*

(Manuscript received May 31, 1958)

Mardell D. Tompkins and George B. Pratt

Research and Technical Department, American Can Company, Maywood and Barrington, Illinois

FLAVOR EVALUATION METHODS have been developed and compared using various foods, but only a few systematic studies have been reported to show their application to citrus products. Furthermore, the problem of sensory fatigue or decrease in taste acuity by continued tasting of citrus juice concentrate has not been appraised.

Investigators in taste test work have reported that fatigue seems prominent in tasting certain types of food products while it is practically negligible in others *(9, 10)*. Also, it has been reported that at least eight samples of some foods can be tasted per session without fatigue *(1, 9)*. Information is lacking in the literature concerning the number of samples of citrus juice concentrate which should be tasted at one session. Because of the marked decrease in taste acuity as successive comparisons were made, Willson and Hanson *(20)* presented only two pairs of samples of orange juice at each taste test session, whereas, Pfaffmann *(15)* reported as many as 75 tastings of synthetic orange drink for each judge in a 40-minute taste test session.

Published data on sensory tests often do not give the temperature of orange juice when tasted. Some authors report that the juice was served at room temperature *(4, 6)*; others have reported that all samples were served at the same temperature, but no temperature is given *(18)*. Carlin, Kempthorne, and Gordon *(2)* evaluated orange juice after reconstitution at a temperature range of approximately 2° C. to 6° C. which was probably the temperature of the juice before it was poured for the judges.

The primary purpose of this study was to compare three taste test techniques for determining the panel's preference among seven samples of frozen orange juice concentrate. Other objectives were to determine if tasting three samples arranged according to an incomplete latin square design gave finer discrimination by the panel than when all seven samples were tasted per session; and to determine if the temperature (refrigerator and room) of the juice affects the judges' sensitivity.

EXPERIMENTAL PROCEDURE

Seven variables of frozen orange juice concentrate were shipped directly to Maywood, Illinois, by a Florida producer.

Instructions to panel and arrangement of samples. Since interest and the desire to do well are important in the success of any taste panel, the judges were given all possible information concerning the tests. However, precaution was taken to prevent bias and to conceal the identity of the variables. The samples were randomized in order of presentation to avoid special effects such as "position" and "contrast" described by Peryam and Pilgrim *(14)*. The randomized samples were presented simultaneously to the judges, who were instructed to taste from left to right. In tasting citrus products the tasters use their own judgment about whether to swallow or not to swallow the product, to rinse between samples, or to wait a few minutes between samples.

Taste test methods. The 7 variables of frozen concentrated orange juice were reconstituted with Corinnis spring water. The temperature of the juice in the waxed paper cups at the time of tasting was 50° F. to 55° F. (10° C. to 12.8° C.).

The samples were ranked by 18 judges at a morning session and again at an afternoon session on the same day. The samples were scored on a "quality rating" scale and checked on a hedonic scale in like manner on separate days. The same 18 judges participated in all tests. Designs of the ranking, "quality rating," and hedonic scales are given in Figure 1. The ranks were transformed to scores according to Fisher and Yates *(5)* for normalizing ranked data and were subjected to analysis of variance *(7)* with subsequent calculation of the least significant difference *(17)*. The points checked on the hedonic scale were scored according to Peryam and Pilgrim *(14)*, then these scores and the scores checked on the "quality rating" scale were subjected to three-factor (juice, judge, replication) analysis of variance and calculation of least significant difference *(17)*.

Figure 1. Designs of ranking, "quality rating" and hedonic scales.

Ranking[1]		"Quality rating" scale	Hedonic scale[2]
1. Like most	1	Excellent	Like extremely
2.	2		
3.	3	Good	Like very much
4.	4		Like moderately
5.	5	Fair	
6.	6		Like slightly
7. Like least	7	Poor	Neither like nor dislike
	8		Dislike slightly
	9	Extremely poor	Dislike moderately
			Dislike very much
			Dislike extremely

[1] Ranks transformed to scores according to Fisher and Yates (5) 1 = 1.35; 2 = 0.76; 3 = 0.35; 4 = 0; 5 = −0.35; 6 = −0.76; 7 = −1.35

[2] Points checked on scale scored with 9 = Like Extremely and 1 = Dislike Extremely

Sensory fatigue — seven versus three samples per block. Eighteen judges checked the 7 variables on a hedonic scale two times, making a total of 36 tastings per sample. Fourteen judges evaluated 6 three-sample blocks on a hedonic scale, making a total of 36 tastings per sample. In this test, 2 three-sample blocks were tasted at each of 3 sessions with at least a 5-minute wait between blocks.

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, May 27, 1958, Chicago, Illinois.

The results involving the three-sample blocks were analyzed according to Cochran and Cox *(3)*.

Temperature of samples — refrigerator versus room temperature. Twenty judges evaluated 2 samples of frozen orange juice concentrate which were found to be significantly different at a previous test. Each judge checked on a hedonic scale 3 sets of samples at 2 sessions. At each session 10 judges tasted the refrigerated samples first, and 10 judges tasted the room temperature samples first. The 2 variables were randomized and each was tasted first the same number of times. Product temperatures at the time of tasting ranged from 50° F. to 55° F. (10° C. to 12.8° C.) for the refrigerated samples and from 74° F. to 76° F. (23.3° C. to 24.4° C.) for the room temperature samples. A four-factor (juice, temperature, judge, replication) analysis of variance *(17)* was applied to the scores.

RESULTS AND DISCUSSION

Data summarized in Table 1 indicate a satisfactory agreement in the ranking of samples by the three different taste test techniques. The three techniques (ranking, "quality rating," and hedonic scale) show: Code 42-B is rated higher than all other variables; Codes 40-5 and 40-3 are not significantly different from one another and are rated in second place; and Code 37-2 is rated the lowest. The scores for Codes 37-3, 41-1 and 37-1 indicate a gradual decrease in rating by the three taste test techniques when the least significant difference values are applied, but there is no complete agreement as to the significant differences between these variables. Nevertheless, these results indicate that the ranking, "quality rating," and hedonic scale techniques are satisfactory methods for evaluating samples of frozen orange juice concentrate.

TABLE 1

Evaluation of frozen orange juice concentrate by ranking, "quality rating," and hedonic scale techniques

Codes	Ranking mean scores	"Quality rating" mean scores	Hedonic scale mean scores
42-B	1.02	1.58	8.48
40-5	0.52	2.42	7.53
40-3	0.30	2.83	7.25
37-3	−0.01	3.69	6.92
41-1	−0.23	3.91	6.56
37-1	−0.41	4.19	5.55
37-2	−1.19	6.36	4.39
Least significant difference at 5%	0.30	0.66	0.70
Distinctions[1]	18	17	16

[1] The number of significantly different scores calculated from the array of the mean scores at the 5% level of significance.

Evaluation of taste test methods. Many statistical yardsticks have been used in comparing taste test methods. Probably none of these procedures for comparison is universally acceptable or invulnerable to criticism. Three different procedures were used to compare the tests described in this paper.

A simple and direct comparison is provided by the number of significantly different varieties or treatments in the array of mean scores from each taste test method *(8, 13)*. It is hoped that those who object to the use of the "least significant difference" for multiple distinctions will, at any rate, permit its use in providing a fair comparison of methods. The method providing the largest number of "significant" distinctions is presumably the most sensitive.

An intuitively appealing procedure for comparison of taste test methods where degrees of freedom are comparable is the simple comparison of variance ratios (F) produced by the respective methods. The higher the variance ratios (F), the more clearly significant are the differences.

Another statistical technique which has been used to evaluate methods using different scales is Kramer's *(13, 19)* sample number ratio multiplied by the number of tastings (SNR × N). In this formula, N is total number of tastings, and SNR is

$$\left(\frac{\text{LSD treatment .01}}{\text{Range of treatment means}}\right)^2.$$

The resulting value indicates the sensitivity of the test method: the lower the value, the more sensitive the method.

Some investigators *(11, 13)* have used the degree of significance levels and/or the number of individual judges or individual panels who detected significant differences to evaluate methods. This procedure was not applied to the data in this paper.

Comparison of taste test techniques in Table 2 by number of distinctions, variance ratios (F), and SNR × N suggests that the ranking test shows finer discrimination among the seven variables of frozen orange juice than either the "quality rating" or hedonic scale technique. This apparent superiority is, however, somewhat suspect because of the well-known underestimation of error variance encountered with ranking techniques *(16)*.

Table 2 also shows slightly greater sensitivity by the judges with the "quality rating" scale as compared to the hedonic scale. But this does not prove method superiority because the judges have had more experience with the "quality rating" scale, and have expressed a liking for unnamed intervals on rating scales. It is very likely that with equal experience with the two rating scales, the judges' ability to discriminate among samples would not differ.

Therefore, the results of these studies should be considered in terms of possible differences in the statistical analysis and the panel's training. Comparisons of this type mean only that with a particular

TABLE 2

Comparison of various taste test techniques

	Total tastings per sample	Variance ratio (F)[1]	Distinctions[2]	SNRxN[3]	LSD[4] 5%	LSD[4] 1%
Ranking (7 sample)	36	45.24	18	8	0.30	0.39
"Quality rating" (7 sample)	36	42.15	17	9	0.66	0.88
Hedonic scale (7 sample)	36	28.77	16	13	0.70	0.93

[1] Variance Ratio (F) for 6 and 102 degrees of freedom in every case. Sample Mean Square divided by Sample x Taster Interaction.

[2] Distinctions are number of significantly different scores—calculated from the array of mean scores at the 5% level of significance.

[3] Kramer's SNR x N formula. N is total number of tastings and SNR is $\left(\frac{\text{LSD treatment .01}}{\text{Range of treatment means}}\right)^2$

[4] Least Significant Difference calculated according to Snedecor *(17)*.

problem, panel and product, and under the exact conditions of the test, one method appeared better than another. Mitchell *(12)* reports that there is no superior method but each method in its proper use is psychologically sound and each probably has specific application in which it will give superior results.

By whatever means the different taste test methods are evaluated, certain precautions are in order. Even if the same product is judged by different techniques on the same day, the method used first might result in training, thereby improving the performance for the next method tested. Furthermore, the statistical analysis of the results and the judges' understanding of, preference for, and experience with each technique and each rating sheet should be comparable before one method can be judged as better than another. Therefore, taste test methods should not be judged superior without careful study of factors which might influence the mathematical efficiency shown by the evaluation of the methods by various statistical techniques.

Sensory fatigue—seven versus three samples. Data in Table 3 show that the judges could discriminate just as well with seven as with three variables per block of tasting. Tasting three samples per block arranged according to an incomplete latin square design required greater expenditure of time by the judges and those who supervised the tests than did tasting seven samples per session. Furthermore, the statistical analysis of the scores in the three-sample test was more complicated and time consuming.

TABLE 3

Evaluation of seven variables of frozen orange juice concentrate—seven versus three samples

Codes	Hedonic scale[1]		
	Seven samples	Codes	Three samples
	Mean scores (36 tastings per variable)		Adjusted mean scores (36 tastings per variable)
42-B	8.48	42-B	8.36
40-5	7.53	40-3	7.37
40-3	7.25	40-5	7.09
41-1	6.92	41-1	6.77
37-3	6.56	37-3	6.58
37-1	5.55	37-1	6.49
37-2	4.39	37-2	4.46
Least significant difference at 5%	0.70		0.58
Distinctions[2]	16		15

[1] Points checked on scale scored with 9 = Like Extremely and 1 = Dislike Extremely.

[2] Distinctions are number of significantly different scores—calculated from the array of mean scores at the 5% level of significance.

Temperature of samples—refrigerator versus room temperature. Preliminary work indicated the difficulty in keeping the temperature constant when cold juice is served. The temperature of the juice will increase when it is poured into paper cups or glass containers at room temperature and will continue to increase until the juice is tasted.

In order to test the effect of temperature of juice upon the judges' ability to discriminate between variables, samples of juice which are significantly different must be used; however, the difference must not be too great or the test will be wasted effort.

Analysis of variance of the 240 scores showed that the tasters preferred the refrigerated juice and that they preferred Code 2 at both temperatures. More important, however, was the lack of significance of the temperature-juice interaction, indicating that there was no difference in discrimination between the codes at room temperature and at refrigerator temperature. The average scores as well as the analysis of variance are presented in Table 4.

TABLE 4

Effect of temperature of juice upon judges' ability to discriminate between samples

Temperature of juice[1]	Code 1 Mean scores[2]	Code 2 Mean scores[2]	Difference
Refrigerator (50°–55° F.)	7.2	7.8	0.6
Room temperature (74°–76° F.)	6.5	7.2	0.7

[1] Temperature of juice in paper cup at time of tasting.

[2] Points checked on scale scored with 9 = Like Extremely and 1 = Dislike Extremely.

Analysis of variance

Source of variation	Degrees of freedom	Mean square	Test of significance
Temperature	1	24.0667	$F^{1}_{19} = 23.329^{b}$
Sample	1	26.6667	$F^{1}_{19} = 16.889^{b}$
Judge	19	7.4377	Not tested
Replication	2	0.3500	$F^{2}_{35} = 0.565$
Temp. x sample	1	0.4166	$F^{1}_{135} = 0.673$
Temp. x judge	19	1.0316	$F^{19}_{135} = 1.666^{a}$
Temp. x repl.	2	0.4667	$F^{2}_{135} = 0.754$
Sample x judge	19	1.5789	$F^{19}_{135} = 2.550^{b}$
Sample x repl.	2	0.1167	$F^{2}_{135} = 0.188$
Judge x repl.	38	0.8719	$F^{38}_{135} = 1.408$
Error	135	0.6191	
Total	239		

[a] Significant at 5% level.

[b] Significant at 1% level.

SUMMARY

The three taste test techniques, ranking, "quality rating," and the hedonic scale showed satisfactory agreement in comparing seven samples of frozen orange juice concentrate. Under the particular conditions of these tests the ranking technique appeared to offer the most precision, followed by the "quality rating" scale.

Eighteen judges were able to taste seven samples of frozen orange juice concentrate per session without apparent fatigue.

The panel found a difference between two samples of orange juice concentrate at each temperature range [(50° F. to 55° F.) and (74° F. to 76° F.)] but the difference between the scores for the two samples was not altered significantly by temperature of tasting.

LITERATURE CITED

1. Bradley, J. E., Walliker, C. T., and Peryam, D. R. Influence of continued testing on preference ratings. *Food Acceptance Testing Methodology—a Symposium*, p. 92. Advisory Board on Quartermaster Research and Development, Committee on Foods, National Academy of Sciences—National Research Council (October 1954).

2. Carlin, A. F., Kempthorne, O., and Gordon, J. Some aspects of numerical scoring in subjective evaluation of foods. *Food Research*, **21**, 273 (1956).

3. Cochran, W. G., and Cox, G. M. *Experimental Design*. Chapter 13. 1950. John Wiley and Sons, Inc., New York, N. Y.

4. Coote, G. G. Analysis of scores for bitterness of orange juice. *Food Research*, **21**, 1 (1956).

5. Fisher, R. A., and Yates, F. *Statistical Tables*. Table XX. 1948. Oliver and Boyd, Edinburgh, Scotland.

6. Hill, E. C., and Wenzel, F. W. The diacetyl test as an aid for quality control of citrus products. I. Detection of bacterial growth in orange juice during concentration. *Food Technol.*, **11**, 240 (1957).

7. Kempthorne, O. *Design and Analysis of Experiments*. 1952. Wiley and Sons, New York, N. Y., p. 157.

8. Kramer, A., and Ditman, L. P. A simplified variables taste panel method for detecting flavor changes in vegetables treated with pesticides. *Food Technol.*, **10**, 155 (1956).

9. Krum, J. K. Truest evaluations in sensory panel testing. *Food Eng.*, **27** (7), 74 (1955).

10. Laue, E. A., Ishler, N. H., and Bullman, G. A. Reliability of taste testing and consumer testing methods. I. Fatigue in taste testing. *Food Technol.*, **8**, 387 (1954).

11. Mahoney, C. H., Stier, H. L., and Crosby, E. A. Evaluating flavor differences in canned foods. I. Genesis of the simplified procedure for making flavor difference tests. *Methodology of Sensory Testing. Food Technol.*, **11** (9) Insert, pp. 29–37 (1957)

12. Mitchell, J. W. Flavor evaluation still has a long way to go. *Food Eng.*, **28** (7), 46 (1956).

13. Murphy, E. F., Covell, M. R., and Dinsmore, J. S., Jr. An examination of three methods for testing palatability as illustrated by strawberry flavor differences. *Food Research*, **22**, 423 (1957).

14. Peryam, D. R., and Pilgrim, F. J. Hedonic scale method for measuring food preferences. *Methodology of Sensory Testing. Food Technol.*, **11** (9) Insert, pp. 9–15 (1957).

15. Pfaffmann, C., Schlosberg, H., and Cornsweet, J. Variables affecting difference tests. *Food Acceptance Testing Methodology—A Symposium*. p. 4. Advisory Board on Quartermaster Research and Development, Committee on Foods, National Academy of Sciences—National Research Council (October 1954).

16. Reimer, C. Some applications of rank order statistics in sensory panel testing. *Food Research*, **22**, 629 (1957).

17. Snedecor, G. W. *Statistical Methods*. 5th ed. 1956. The Iowa State College Press, Ames, Iowa.

18. Swift, L. J., and Veldhuis, M. K. Composition of commercial, segment, and peel juices of Florida oranges. *J. Agr. Food Chem.*, **5**, 49 (1957).

19. Wiley, R. C., Briant, A. M., Fagerson, I. S., Sabry, J. H., and Murphy, E. F. Evaluation of flavor changes due to pesticides—a regional approach. *Food Research*, **22**, 192 (1957).

20. Willson, A. E., and Hanson, W. D. "Paired comparison" taste panel procedures for citrus juice. *Fla. State Hort. Soc. Proc.*, **65**, 258 (1952).

Influence of Acronizing on Organisms Causing Spoilage in Commercially Processed Fryers

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A NUMBER OF REPORTS have appeared in the literature indicating that the use of chlortetracycline on chilled poultry brings about a change in the microbiological flora associated with spoilage. For example, in 1955, Ziegler and Stadelman *(8)* claimed that yeasts are the predominant organisms associated with spoiling fryers which had been treated with chlortetracycline. The untreated controls at time of spoilage showed a predominance of Gram-negative, rod-shaped bacteria.

In 1956, Ayres *et al. (1)* showed that the relative proportion of yeasts to bacteria on spoiled chicken which had been treated with chlortetracycline was much higher than for untreated birds. However, the Gram-negative *Pseudomonas-Achromobacter* bacteria were still the predominant type of organisms associated with the spoiled carcasses. Similar results have also been reported by Wells *et al. (5)* and Silvestrini, Anderson and Snyder *(3)*.

Yacowitz *et al. (7)* reported in 1957 that the spoilage of chlortetracycline-treated chicken is caused by yeasts, thus corroborating the claim of Zeigler and Stadelman *(8)*, and Wells and Stadelman *(6)*. Combined treatments of chlortetracycline and Mycostatin (an antibiotic active against yeasts) effectively inhibited bacterial and yeast growth and further extended the shelf life of chicken (compared to untreated controls of chlortetracycline-treated birds).

The present authors have made a number of studies of the factors influencing the shelf-life of fryers. Both plant sanitation and antibiotics have been found to influence microbiological contamination and shelf-life *(2, 4)*. In the course of these investigations, hundreds of commercially processed birds have been stored and examined for off-odor and microbiological condition. Yeasts have never been observed in numbers sufficient to be considered significant. Odor panel evaluations of spoiled birds have seldom revealed a yeasty condition. As a result of this experience it was postulated that chlortetracycline treatment can cause a shift in the types of organisms associated with spoilage; however, under commercial conditions such a shift seldom, if ever, occurs. The present experiment was set up to test this postulate.

PROCEDURE

A substantial number of packages of cut-up, tray-packed fryers were obtained from retail markets in the Sacramento, California, area. An effort was made to get birds which had been treated by the Acronize process and birds which had not been treated with an antibiotic. Some of the birds had been grown and processed in states other than California. Exact dates of processing were not known.

Immediately after purchasing, the birds were brought to Davis and placed in a chill room maintained at 40° ± 3° F. for 7 days. (It had been established that incipient or actual spoilage occurred within this period of time.) After storage the birds were taken to the laboratory for microbiological examination.

After removing the clear plastic film (most commonly cellophane or pliofilm), one square inch of thigh surface was scrubbed with a sterile calcium alginate swab. The swab was placed in a test tube containing sterile 1% Calgon solution; the contents were thoroughly shaken, appropriately diluted and plated. Eugonagar (Baltimore Biological Laboratory) was used for total psychrophile count and wort agar (made of 5% wort plus 1.5% agar, adjusted with 10% tartaric acid to pH 3.5 just prior to pouring the plates) for the yeast count. The Eugonagar plates were incubated at 40° F. for 7 days; the wort agar plates at 68° F. for 3 days. These incubation conditions had previously been shown to give maximal counts. Numbers were estimated from duplicate plates using a Quebec colony counter. Smears were taken from colonies on both Eugonagar and wort agar and were examined microscopically for morphological characteristics.

RESULTS

Thirty-six fryers were examined during the course of this study. Each bird represented a shipment from a given plant for a particular week. Thus, while only a relatively small number of birds were examined, they represented a number of shipments from many different plants. They were obtained from self-service meat counters of 7 different stores. The majority of the birds had been processed in California; however, a few birds came from processing plants located in Alabama and Georgia. Eleven of the 36 fryers had been treated by the Acronize process (as indicated by label declaration); the remainder had not.

Pertinent data on the test birds are given in Table 1. The average count for all samples plated on Eugonagar was 455,000,000; for wort agar the average count was 64,000. The average count on Eugonagar for the Acronized fryers was 147,000,000; for wort agar the count was 18,900. Microscopic examination of smears from the colonies on the plates showed that those from Eugonagar were predominantly Gram-negative rods, whereas those from wort agar were yeasts. Occasional mold colonies were also noted on the wort agar plates.

TABLE 1

Effect of origin and acronize treatment on microbial populations of spoiled fryers

Source	Code No.	Acronize treatment	Counts per sq. inch	
			Total No. x 10^6	Yeasts No. x 10^2
Alabama	43M	No	1.4	2.6
Alabama	47M	Yes	4.4	36.0
Alabama	51M	Yes	1.1	1.3
Alabama	54M	Yes	.8	15.0
Alabama	60M	Yes	.9	9.9
Alabama	64M	Yes	3.2	.1
Alabama	68M	Yes	.001[1]	1.0
Alabama	76M	Yes	1.0	7.7
Alabama	79M	Yes	.03	2.2
California	44M	No	6.2	.5
California	45M	No	4.5	.4
California	46M	No	9.8	1.8
California	48M	No	4.0	1.0[1]
California	50M	No	2.8	6.6
California	52M	No	14.0	4.5
California	53M	No	18.0	4.7
California	55M	No	7.4	26.0
California	56M	No	4.0	1800.0
California	57M	No	11.0	2.4
California	59M	No	3.2	0.2[1]
California	63M	No	.4	.1[1]
California	65M	No	4.3	1.7
California	66M	No	1.9	.6
California	67M	No	5.3	3.0
California	69M	No	2.4	6.3
California	71M	No	7.2	0.1[1]
California	72M	No	5.3	.4
California	74M	No	16.0	160.0
California	77M	No	8.0	3.3
California	78M	No	5.9	5.0
California	81M	No	1.8	23.0
California	75M	Yes	.5	0.0[1]
Georgia	49M	Yes	.04	2.6
Georgia	58M	Yes	.4	16.0
Georgia	61M	Yes	.8	150.0
Georgia	70M	Yes	5.9	3.8

[1] Count based on less than 30 colonies per plate.

These results clearly show that the spoilage of these commercially processed fryers was accompanied by a flora made up predominantly of bacteria. In no instance did the yeast count even approach that for bacteria. These results agree with those of Ayres *et al. (1)* but conflict with those of Ziegler and Stadelman *(8)* and Yacowitz *et al. (7)*. It should be pointed out that the birds used in the present experiment were commercially processed. Most of the birds used by Ziegler and co-workers and Yacowitz and co-workers were processed under non-commercial conditions. From the results of the present experiment it seems that whether or not chlortetracycline is used, spoilage of commercially processed fryers generally is accompanied by very high bacteria counts. High yeast counts and yeasty off-odors do not appear to be common conditions in such poultry.

There appear to be several reasons why yeasts do not replace bacteria as the predominating spoilage flora in commercially processed poultry which has been treated with chlortetracycline. First of all, the initial bacteria counts on commercially processed birds is enormous relative to yeast counts [Ayres *et al. (1)*]. Then, too, some of the bacteria present on the carcass are in an active phase of growth (especially the bacteria picked up from contaminated surfaces) [Ng *et al. (2)*]. Furthermore, it has also been shown by Ng *et al. (2)* that chlortetracycline-resistant strains are present under commercial conditions of antibiotic use. Finally with the temperatures prevailing in fryers during commercial handling and distribution (32°–50° F.) bacterial growth is favored over yeasts. After consideration of these factors, it is not surprising that bacterial growth far outstrips yeast growth in commercially processed fryers, even in the presence of chlortetracycline.

SUMMARY

Thirty-six fryers representing commercially processed birds from a number of plants located in California, Georgia, and Alabama, with and without Acronize treatment were obtained from several retail stores in the Sacramento, California, area. After storage for 7 days at 40° F., the birds were examined microbiologically. All birds were found to have high bacteria counts; the yeast counts were relatively low and in no case did they approach the bacteria counts. It is concluded that spoilage in commercially processed fryers, whether Acronized or not, may be attributed to bacterial rather than yeast growth.

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LITERATURE CITED

1. Ayres, J. C., Walker, H. W., Farnelli, M. J., King, A. W., and Thomas, F. Use of antibiotics in prolonging storage life of dressed chickens. *Food Technol.*, **10**, 563 (1956).

2. Ng, Henry, Vaughn, R. H., Stewart, G. F., Nagel, C. W., and Simpson, K. Antibiotics in poultry meat preservation: Development of resistance among spoilage organisms. *Applied Microbiol.*, **5**, 331 (1957).

3. Silvestrini, D. H., Anderson, G. W., and Snyder, E. S. Chlortetracycline as related to the microbiology and preservation of poultry meat. *Poultry Sci.*, **37**, 179 (1958).

4. Vaughn, R. H., Nagel, C. W., Sawyer, F. M., and Stewart, G. F. Antibiotics in poultry meat preservation: A comparison of the tetracyclines. *Food Technol.*, **11**, 426 (1957).

5. Wells, F. E., Fry, J. L., Marion, W. W., and Stadelman, W. J. Relative efficacy of three tetracyclines with poultry meat. *Food Technol.*, **11**, 656 (1957).

6. Wells, F. E., and Stadelman, W. F. Development of yeasts on antibiotic-treated poultry. *Applied Microbiol.*, **6**, 420 (1958).

7. Yacowitz, H., Pansy, F., Wing, S., Stander, H., Sassaman, H. L., Pazano, J. F., and Trejo, W. H. Use of nystatin (Mycostatin) to retard yeast growth on chlortetracycline-treated chicken meat. *Poultry Sci.*, **36**, 843 (1957).

8. Ziegler, F., and Stadelman, W. F. Effect of aureomycin treatment on the shelf life of fresh poultry meat. *Food Technol.*, **9**, 107 (1955).

Tenderness in Beef Muscle as Measured by Pressure*

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INCREASED CONSUMPTION of meat has stimulated research and improvements in organoleptic properties of meat. Today, tenderness is one of the most desired and critical organoleptic qualities in meat (especially beef). Factors of heredity (genetic composition), environment (feeding and management practices), and the age of the animal influence the tenderness of beef. Extensive research studies have tried to establish the physical, chemical, and histological properties of meat that are related to tenderness and the other organoleptic qualities. Because of individual subjective differences in judging tenderness, objective methods have been of assistance as a more precise and reproducible procedure.

Mechanical methods *(13)* applying various principles involved in chewing fibrous foods, have been devised for measuring tenderness. As early as 1907 Lehman *(9)* devised an instrument to determine the breaking strength of fibers and to measure the force required to shear meat between two cutting edges. An apparatus (now known as the Warner-Bratzler shear) was developed in 1928 by Warner *(17)* and was tested by Bratzler, 1932 *(3)*. In 1938 Child and Satorius *(4)* described a modification of the Warner-Bratzler shear-stress apparatus. In this modification, pounds of force were recorded on a gauge as shearing bars were pulled across a dull triangular blade containing the meat samples. Also in 1938 Volodkevich *(16)* devised an instrument to simulate chewing fibrous material. It was composed of a stationary and a mobile wedge each having a dull rounded cutting edge. Force exerted in maceration was recorded as a line curve. In 1955 Proctor *et al. (11)* devised an instrument fitted with synthetic human dentures mechanically arranged to simulate the frequency and motion of chewing. Any opposition to such motion caused by placing food between the teeth was indicated on a strain gauge and recorded on an oscilloscope. Miyada and Tappel *(10)* in 1956 used a modified texturemeter having an electric motor and reduction gears. The shear force required to press shearing prongs through a meat sample was measured. Of all the present instruments the Warner-Bratzler shear having been modified by changing the rectangular cutting blade to one having a triangular orifice, by motorizing to insure a constant rate of pressure, and by addition of a dynamometer for ease in recording has been the most popular and widely used *(13)*. However, Hurwiez and Tischer *(7)* reported unfavorably as to the reliability of the Warner-Bratzler shear.

There have been attempts to determine the nature of tenderness in beef muscle through histological and chemical analysis. Brady *(2)* reported that the number of muscle fibers making up a muscle bundle was related to tenderness and that the larger the muscle bundle the finer the texture. Ramsbottom, Strandine, and Koonz *(12)* reported great variation in texture of muscles as determined by the size of the muscle bundle. Hiner, Hankins, Sloane, Fellers and Anderson *(5)* in studies of 52 beef animals varying in age from 10-week old calves to 9-year old cows reported that fiber diameter was associated with tenderness. The relationship was found to be curvilinear, and the correlation was 0.83. Histological examination of the same muscles showed that the amount and distribution of collagen and elastin was associated with tenderness, Hiner *et al. (6)*. Husanini, Deatherage, Kunkle and Draudt *(8)* in 1950 in working on the biochemistry of meat reported there was no significant relation of total nitrogen, non-protein nitrogen, trichloracetic acid soluble nitrogen or heat coagulable water soluble nitrogen to tenderness.

The Warner-Bratzler shear values correlate satisfactorily with palatability test values for heated samples. A tender roast or steak can be readily chosen after it is cooked. The packer, retailer, and housewife want to know if the meat is tender before they buy it.

Various systems of grading cattle have been devised. Yet there is no way to predict with any certainty whether an animal will be tough or tender. Only when it is served on the platter is tenderness proven. Some means to predict tenderness before slaughter might enable geneticists to produce a higher proportion of tender beef animals.

The retailer wants to assure the housewife that he handles only tender beef. Many markets make use of every known method to supply their customers with tender meat. The packers are equally concerned that the carcasses bearing their names yield only tender cuts. Present carcass grading systems do not accurately indicate tenderness. There is need for a more accurate estimate of the tenderness of meat before it reaches the consumer's table.

No packer wants a steak cut out of each carcass to test for tenderness. If the tenderness of a sample weighing 30 g. could be measured quickly, with some degree of accuracy, carcasses could be certified as to degree of tenderness.

A device to measure meat tenderness for this specific purpose should meet the following requirements: (a) it should measure the tenderness of a small sample of raw or cooked meat; (b) it should give results quickly and be easy to operate; (c) it should

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give reasonably accurate results on a sample small enough for biopsy. Only requirements (a) and (b) are undertaken in the present study.

With these aims in mind a tenderness press was designed.

METHODS

The tenderness press devised (Plate 1) is a modification of the Carver juice press *(15)*. In the preliminary meat tenderness studies, a pressure gauge measuring from 0 to 3,000 pounds in 25-pound units was found to be the most acceptable of gauges available.

Plate 1. Photograph of tenderness press with cylinder in place.

The Carver cylinder (Plate 2) was also modified. The base (Figure 2, Plate 2) of the modified cylinder made of rust resistant mtal, contained one hole (0.3 cm. in diameter) centrally located. The stainless steel cylinder body was made 8.5 cm. high with a diameter of 6 cm. The orifice of the cylinder body located in the center was 2.8 cm. in diameter. A plunger (Figure 3, Plate 2) fits in this orifice with just enough clearance for free movement.

The meat sample plug was cut, as described below, to fit this opening and a rubber gasket placed on top of the meat before the plunger was inserted. The cylinder, when in use (Plate 3), is placed on another steel block (Figure 4, Plate 2) of similar height from which a rectangular section was removed. This was necessary so that the first protrusion of meat under pressure could be observed.

In order to cut standard meat plugs for use in the cylinder, a tapered corer (Figure 5, Plate 2) was made. The diameter of this corer was such that the cut meat plug (½ inch thickness) would fit snugly in the bore of the cylinder.

The diameter of the chamber and plunger will be reduced to smaller dimensions to measure tenderness of small biopsy samples in continuance of this experiment.

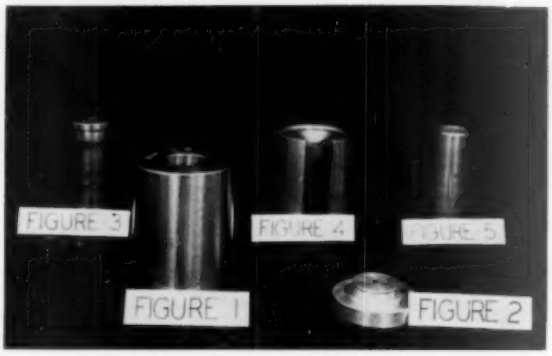

Plate 2. Components of cylinder.

Figure 1. *Cylinder body*
height 8.5 cm.
diameter 6.0 cm.
diameter of center orifice 2.8 cm.

Figure 2. *Base*
diameter of central hole 0.3 cm.
total height 1.7 cm.
upper tier-height 0.75 cm.; diameter 2.75 cm.
lower tier-height 0.95 cm.; diameter 5.0 cm.

Figure 3. *Plunger*
barrel height 7.8 cm. (not including 0.4 cm. height of head)
barrel diameter 2.75 cm.
diameter of head 3.3 cm.

Figure 4. *Steel block* with rectangular section (2.0 cm. width; 3.6 cm. depth) removed
height 7.5 cm.
diameter 6.0 cm.
(Note top indentation on steel block to hold base immobile)

Figure 5. *Corer* tapered to cutting edge
height 8.5 cm.
inside diameter 2.7 cm.

In order to determine the uniformity and the reproducibility of the apparatus a homogenous substance with considerable resistance was necessary. Two substances were chosen: "Play Doh", a plastic used as children's modeling clay, and "Bud", a rubberized substance used in cleaning typewriter keys.

Initially the lever of the hydraulic system was pumped by hand. Later the lever was connected to a rotating microtome (advance mechanism released) so that a fairly consistent stroke was accomplished by hand turning. In each case the operator observed a time clock to judge the strokes with uniformity. Trial runs on both of these systems indicated the reproducibility of the hydraulic system.

In order to apply pressure more uniformly and to eliminate human error as nearly as possible in the hydraulic mechanism, the microtome drive was replaced by a one horse power motor. This drive, going through a gear reduction box, reduced the motor speed to 2.87 strokes/second. Play Doh was used to standardize the motor driven hydraulic press. Three separate trials of 10 samples in each of this homogenous substance determined the accuracy and reproducibility of the tenderness press. Each sample reproduced itself exactly 10 times per trial.

Raw and heated meat samples were tested at room temperature. Raw *Semitendinosus*, *Psoas major*, and *Longissimus dorsi* muscle and heated *Longissimus dorsi* were used in the experiment. The heated samples were cooked in a ventilated electric oven at 325° F. to an internal temperature of 140° F. Sampling and palatability on a 1–7 point scale were performed according to the method developed by the cooking committee of The Cooperative Meat Investigations Project *(1)*. The *Psoas* or tenderloin samples represent the most tender cut of beef, the *Longissimus dorsi* or rib eye, moderately tender, and the *Semitendinosus* or round, a relatively tough cut. The *Longissimus dorsi* also has been the muscle of choice for palatability testing. Samples were cut with the corer from the center cut of the raw *Semitendinosus* and *Psoas* muscles. In the raw and heated samples of the *Longissimus* (9, 10, and 11 rib section) this center cut was next to the 5 slices removed for the

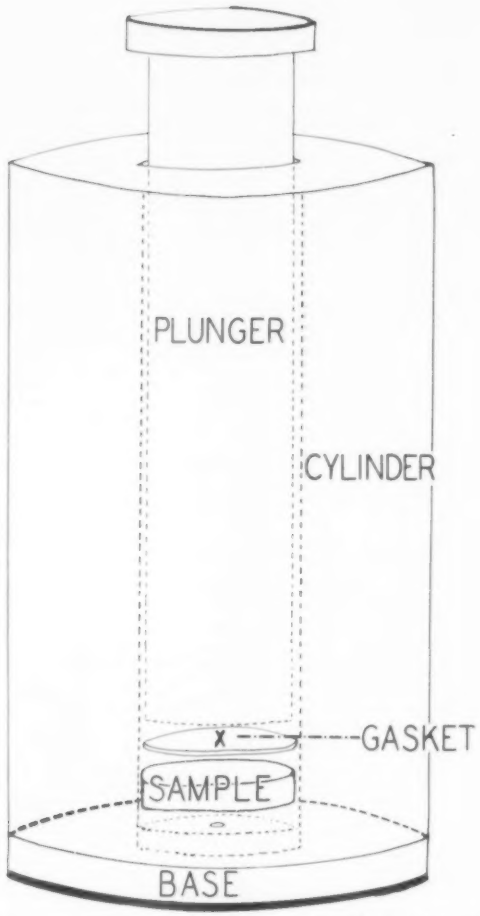

Plate 3. Diagram of cylinder assembled before being placed on steel block.

organoleptic panel. The samples were ½ inch thick. A series of three of these ½ inch samples was taken from each muscle. Raw samples were taken 3 days and 7 days after slaughter. The samples used for heating were taken 10 days after slaughter. The samples were put in the cylinder so that the orifice in the base was perpendicular to the muscle fibers. The reading on the pressure gauge, when the first protrusion of sample muscle (under pressure) appeared in the hole of the disk, was taken as the toughness of that sample. The average of the readings in pounds of pressure for 3 samples was recorded as the toughness of that muscle.

Beef animals being slaughtered from feeding and breeding experiments were used for the tenderness studies. Fifty-seven carcasses (Group I) and 35 beef ribs (Group II) were available. For purposes of this experiment, the breed, sire, feed-lots, etc., were not essential since we were interested in a measure of final tenderness. All animals used had a carcass grade of U. S. Good or Choice.

RESULTS AND DISCUSSION

Raw samples of the *Longissimus dorsi*, *Semitendinosus*, and *Psoas major* muscles from Group I animals were evaluated for tenderness with the newly designed tenderness press. Heated samples of *Longissimus dorsi* were evaluated by the tenderness press, organoleptic panel and Warner-Bratzler shear. Table 1 shows the difference of means among raw muscle and between raw and heated *Longissimus dorsi*.

TABLE 1

Tenderness press—difference of means

Group I					
Muscles	No. sample	Mean	Standard dev.	Diff. of mean	t
Long. d. (raw) and Semi. (raw)	57	329 438	60.39 124.82	109	5.89[1]
Long. d. (raw) and Psoas (raw)	57	329 279	60.39 47.43	50	4.88[1]
Semi (raw) and Psoas (raw)	57	438 279	124.82 47.43	159	8.92[1]
Long. d. (raw) and Long. d. (heated)	57	329 396	60.39 50.05	67	6.39[1]

[1] Significant at 1% level (*14*).

Highly significant differences were exhibited among the raw muscles and between raw and heated *Longissimus dorsi*. That meat is more tender in the raw state than cooked *(12)* is demonstrated between raw and heated *Longissimus dorsi* (Table 1). The significance of the "t" values among the 3 classes of tenderness as represented by the 3 muscles (Table 1) indicates the value of the tenderness press in distinguishing the 3 relative tendernesses.

Since samples could not be taken until Group I carcasses were graded, raw samples were removed 3 or 7 days after slaughter. Raw samples were removed from the Group II ribs 10 days after slaughter. The heated samples were all from meat aged 10 days.

Table 2 shows the correlation coefficients of the raw and heated samples of *Longissimus dorsi* from both Group I and Group II animals. The panel and the Warner-Bratzler shear recorded tenderness on heated samples. The panel, Warner-Bratzler shear, and tenderness press all showed highly significant correlations on heated (aged 10 days) samples of both Group I and Group II ribs. The raw samples (7 and 10 days) of the tenderness press did not show significant results when correlated with the panel and Warner-Bratzler.

TABLE 2

Tenderness correlation coefficient—Longissimus dorsi muscle

	Group I			Group II
Heated samples aged Raw samples aged	10 days 3 days	10 days 7 days	10 days	10 days 10 days
Number of samples	35	22	57	35
Tenderness (Panel) (heated) and Warner-Bratzler Shear (heated)	.....	.....	—.771[2]	—.595[2]
Tenderness (Panel) (heated) and Tenderness Press (heated)	.....	.....	—.355[2]	—.615[2]
Warner-Bratzler Shear (heated) and Tenderness Press (heated)	.....	.....	.479[2]	.337[1]
Warner-Bratzler Shear (heated) and Tenderness Press (raw)	.785[2]	.004	.....	.226
Tenderness (Panel) (heated) and Tenderness Press (raw)	.899[2]	—.017	.....	.199
Tenderness Press (heated) and Tenderness Press (raw)	.415[2]	.046	.....	.....

[1] Significant at 5% level.
[2] Significant at 1% level.

shear. However, the raw samples aged 3 days and measured by the tenderness press showed highly significant correlations with the panel and Warner-Bratzler shear scores on samples aged 10 days. The tenderness press scores of raw samples aged 3 days, correlated significantly with heated (10 days) sample scores measured on the tenderness press. This may suggest that press scores of raw samples aged up to 3 days will correlate significantly with measurements of heated (aged 10 days) samples.

For the past several years the Warner-Bratzler shear has been the means of correlating organoleptic panel score of tenderness in meat with a mechanical score. A mechanical method is more consistent than a human panel, which can vary from day to day. The Warner-Bratzler shear, however, is primarily used on heated samples. A method was needed for use on raw as well as heated meat samples. A hydraulic system, a mechanical adaptation of the Carver juice press, was set up and a meat sample cylinder designed. The apparatus was tested on known homogenates for accuracy. A series of 92 beef muscle samples was used. These samples, though very similar in tenderness quality, still showed highly significant correlations. Since correlation of measurements on similar animals showed significant differences, it is expected that animals of varying degree of age and tenderness would show an even greater range on the tenderness press.

The tenderness press when used to measure tenderness of beef samples cooked after 10 days aging shows a significant correlation with the Warner-Bratzler shear and a highly significant correlation with the taste panel. This indicates it is as accurate a measure of the tenderness of cooked meat as the Warner-Bratzler shear. The tenderness press used to measure the tenderness of raw beef samples aged 3 days, shows a highly significant correlation with the Warner-Bratzler shear and taste panel ratings of meat cooked after the customary aging period of 10 days. This indicates that the tenderness press readings on an approximate 30 g. sample of meat aged 3 days, could be used to estimate the tenderness of the meat at usual cooking time.

At present, studies are being made on muscle samples removed from the beef animals immediately after slaughter and after aging 10 days. These registered pressures of the raw meat samples should compare with heated samples (aged 10 days). This would prove that raw samples from carcasses aged 0–3 days would give a measure of tenderness of the carcass yield when cooked and served. Thus meat could be sold not only with a carcass grade but also a carcass tenderness index.

SUMMARY

The present studies have been made in an effort to find an objective method of determining tenderness in meats (heated and raw) which could be: (1) used to determine carcass tenderness, and (2) adapted to small biopsy samples.

Preliminary trials on representative homogenous materials indicated that the apparatus used would give highly reproducible results.

Tests were made on 3 representative muscles from fifty-seven beef cattle and on one muscle of 35 other beef animals.

The data obtained showed significant differences between muscles; significant correlations between press and organoleptic scores, and between press and Warner-Bratzler shear; and a significant correlation between heated and raw samples.

Tenderness was determined in raw *Longissimus dorsi* aged up to 3 days and in *Longissimus dorsi* aged 10 days and then heated.

Continuance of the experiment with smaller scale apparatus for biopsy tests seems feasible.

LITERATURE CITED

1. Alexander, L. M., Clark, N. G., and Howe, P. E. Methods of cooking and testing meat for palatability. Supplement to National Project of the Cooperative Meat Investigations, Bureau of Human Nutrition and Home Economics and Bureau of Animal Industry, U. S. Department of Agriculture (1933).
2. Brady, D. E. A study of the factors influencing tenderness and texture of beef. *Proc. 30th Ann. meeting Am. Soc. Animal Production* (1937).
3. Bratzler, Lyman J. Physical research in meat (final report) U.S.D.A. and Kansas State Experiment Station (1933). (M.S. thesis, Kansas State. Measuring tenderness of meat by means of a mechanical shear, 1932).
4. Child, A. M., and Satorius, M. J. Effect of coagulation on press fluid, shear force, muscle-cell diameter, and composition of beef muscle. *Food Research*, **3**, 619 (1938).
5. Hiner, R. L., Hankins, O. G., Sloane, H. S., Fellers, C. R., and Anderson, E. E. Fiber diameter in relation to tenderness of beef muscle. *Food Research*, **18**, 364 (1953).
6. Hiner, R. L., Anderson, E. E., and Fellers, C. R. Amount and character of connective tissue as it relates to tenderness in beef muscle. *Food Technol.*, **9**, 80 (1955).
7. Hurwicz, H., and Tischer, R. G. Variation in determinations of shear force by means of the Bratzler-Warner Shear. *Food Technol.*, **8**, 391 (1954).
8. Husaini, S. A., Deatherage, F. E., Kunkle, L. E., and Draudt, H. N. Studies on meat. I. The biochemistry of beef as related to tenderness. *Food Technol.*, **6**, 313 (1950).
9. Lehman, K. B. Studies of the causes for the toughness of meat. *Arch. Hyg.*, **63**, 134 (1907).
10. Miyada, D. S., and Tappel, A. L. Meat tenderization. I. Two mechanical devices for measuring texture. *Food Technol.*, **10**, 142 (1956).
11. Proctor, B. E., Davison, Sol, Malecki, G. J., and Welch, May. A recording strain-gage denture tenderometer for foods. I. Instrument evaluation and initial tests. *Food Technol.*, **9**, 471 (1955).
12. Ramsbottom, J. M., Strandine, E. J., and Konz, C. H. Comparative tenderness of representative beef muscle. *Food Research*, **10**, 497 (1945).
13. Schultz, H. W. Mechanical methods of measuring tenderness of meat. Proc. Tenth Reciprocal Meat Conference, National Live Stock and Meat Board, Chicago, Ill. (1957).
14. Snedecor, G. W. *Statistical Methods*. 1956. The Iowa State College Press, Ames, Iowa, 422 pp.
15. Tanner, B., Clark, N. G., and Hankins, O. G. Mechanical determination of the juiciness of meat. *J. Agr. Research*, **66**, 403 (1943).
16. Volodkevich, N. N. Apparatus for measurements of chewing resistance or tenderness of foodstuffs. *Food Research*, **3**, 221 (1938).
17. Warner, K. F. Progress report of the mechanical test for tenderness of meat. *Proc. Am. Soc. Animal Production* 114 (1928).

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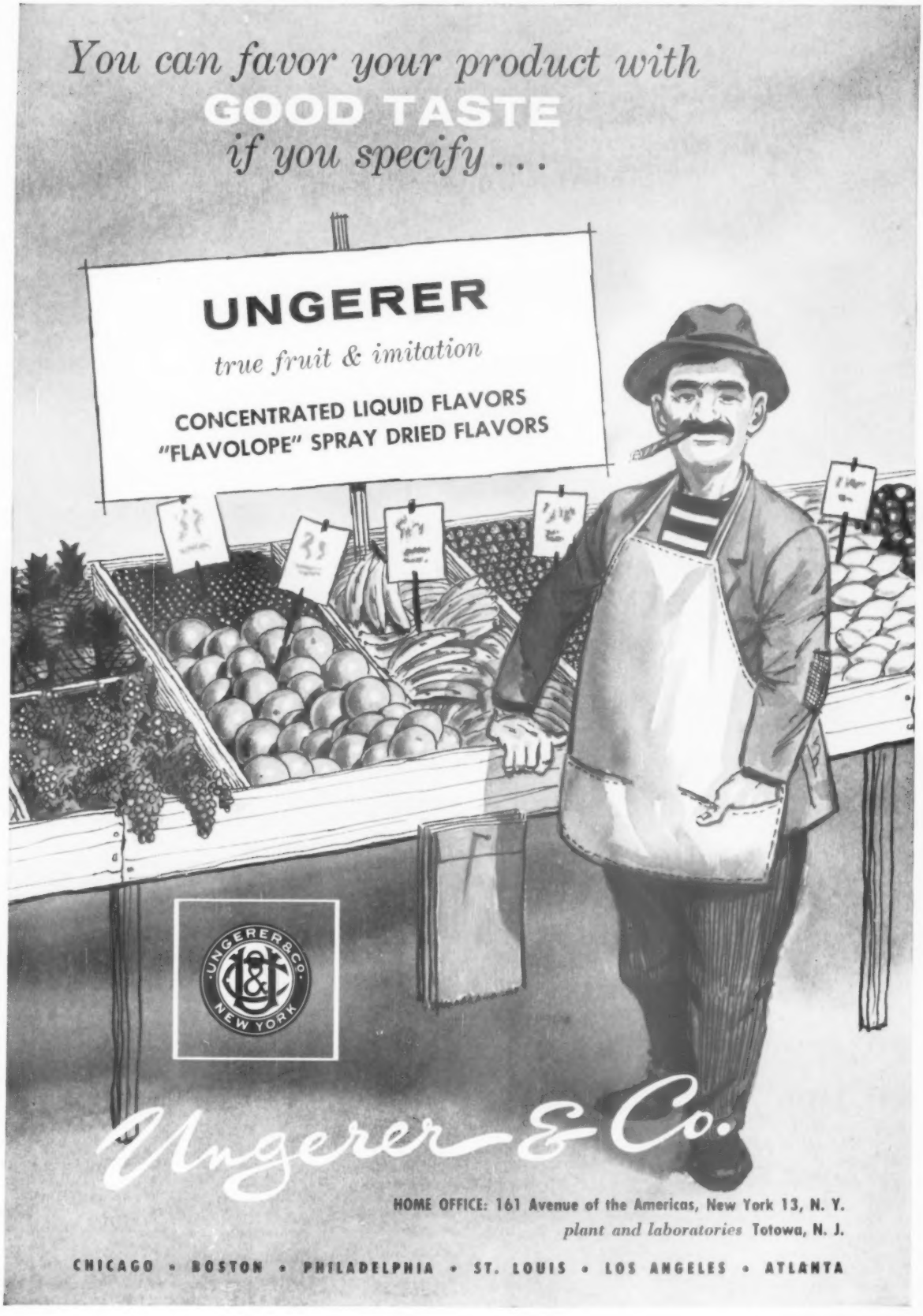

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Storage Rot Susceptibility of Potato Tubers Exposed to Minimum Sprout Inhibiting Levels of Ionizing Radiation*

(Manuscript received September 27, 1958)

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IONIZING IRRADIATION of potato tubers inhibits sprouting in storage and has been suggested as a means of prolonging the storage life of this crop *(6)*. Such treatment, however, has resulted in rot problems. Radiation intensities of 15 kilorep and above predispose tubers to rot*(3)*. This research is a part of a coordinated study on portions of the same lot of potatoes used for storage studies at Purdue University and at Michigan State University. The trial was designed to determine the influence of irradiation intensity on tuber rot incidence, and spread of rot through tuber tissue at minimum levels known to be effective for sprout inhibition.

Gamma irradiation at levels of 15 kilorep and lower was used to determine if the sprouting of stored tubers could be inhibited without a marked increase in the incidence of rot. In order to evaluate the influence of gamma irradiation on incidence of rot at these low levels of intensity, tubers were exposed to infection by two important potato tuber diseases, bacterial soft rot and Fusarium dry rot.

MATERIALS AND METHODS

Potato tubers were radiated with gamma rays from a cobalt 60 source at the Fission Products Laboratory, University of Michigan, Ann Arbor, Michigan. Radiation levels of 0, 5.0, 7.5, 10.0, 12.5, and 15.0 kilorep were employed.

Tubers for these trials were grown at the following locations: Sebago—muck soil, North Judson, Indiana; Red Pontiac—muck soil, Hollandale, Minnesota; Russet Burbank—Blackfoot, Idaho; and Katahdin—Presque Isle, Maine. Sebago tubers were B size ranging in diameter from 1½ to 2 inches. These tubers were stored at 34–40° F. until the day of radiation. The reason for using small sized tubers was to increase the number of tubers in a given treatment without the entire lot being so large that handling would be difficult. The other 3 varieties were U. S. No. 1 commercial grade tubers ranging in diameter from 2 to 3½ inches.

Treatments were as follows: (1) no treatment (a control which was not wounded); (2) control 1 (C-1) noninoculated tubers wounded in a manner similar to that for inoculation, this wounding being accomplished before irradiation: (3) control 2 (C-2) similar to control 1 except that wounding was accomplished after radiation; (4) inoculation 1 (I-1) inoculated before radiation using a mechanical method of introducing inoculum; and (5) inoculation 2 (I-2) similar to inoculation 1 except that it was accomplished after radiation. Bacterial soft rot incited by *Erwinia carotovora* (L. R. Jones) Holland and Fusarium dry rot incited by *Fusarium sambucinum* Fuck. form 6 Wr. (*Fusarium roseum* Link emend. Synder and Hansen) were used as representative diseases for these tuber rot studies.

Cultures of *Fusarium sambucinum* form 6 were obtained from Dr. G. W. Ayers, Science Service Laboratory, Charlottetown, P.E.I., Canada. Isolates of *E. carotovora* obtained from Dr. Reiner Bonde of the University of Maine were subcultured, tested on potato slices and used in the early trials. In later irradiation tests, fresh isolates of *E. carotovora* were obtained from soil by way of carrot slice isolation and tested for pathogenicity on potato tuber tissue.

Inoculation was accomplished using a modification of the method of Ayers and Robinson *(1)*. This consisted of wounding tubers to a uniform depth by punching 2 blunt 16 penny nails through the tuber skin to a depth of 10–12 mm. These nails were mounted 10 mm. apart on a block of wood, and the tuber rolled over this block during the wounding operation. Each tuber was wounded in 2 distinct areas making a total of 4 punctures on the tuber surface. After wounding, the tubers were immersed in a suspension of either fungus spores or bacterial cells. Tubers were placed between 2 layers of damp Sphagnum moss and packed in paper bags in a storage held at the desired temperature. Inoculation either preceded or followed irradiation by not over 6 hours. In the early trials, bacterial soft rot inoculum consisted of a 1-10 dilution of a 5 day nutrient-dextrose broth culture. Later a culture of similar age was diluted 1–5 for use in inoculation. Fusarium rot inoculum consisted of a spore suspension from a 5 to 7 day-old culture of *Fusarium sambucinum* form 6 grown on potato-dextrose agar. The spore suspension was standardized at approximately 200,000 spores per ml.

Each trial was repeated at least 3 times at intervals of approximately 2 weeks. Tubers were prepared in bags and taken to the Fission Products Laboratory at Ann Arbor and returned to East Lansing after radiation. In cold weather, transportation was with a covered, heated truck. The smallest samples with the Sebago B size tubers were 5 pounds, comprising approximately 35–42 tubers. More than 210 pounds of B size tubers were radiated for each replication at each of the storage temperatures. Trials were begun at both 60–70° F. and at 40° F. Because of the low incidence of rot at the 40° F. level, subsequent experiments were limited to the 60–70° F. temperature. Data from 3 separate trials were combined for presentation in graphs. One series of 3 radiation tests was accomplished in January and in early February. A second series of radiation trials was conducted at the normal close of the storage period in April. The third trial was radiated past the close of the normal storage period in July. Samples of Russet Burbank, Katahdin, and Red Pontiac were radiated only during April and in the first week of May.

Since all tubers had been stored at 40° F. there was little breakdown at the time of irradiation. Rot incidence at 60–70° F. was determined 30 days after irradiation and again after 90 days. At the 30 day reading, tubers with visible, external evidence of rot were cut to confirm the diagnosis and to determine

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the spread of rot as measured in mm. through the tissue. The percentage of tubers showing rot was calculated. After 90 days in storage, all tubers were cut and similar data obtained. Rot development at 40° F. was very slow, and storage periods of 100 to 190 days were required for obtaining satisfactory data.

RESULTS

The plan of the trials is outlined in Tables 1 and 2. Observations on treatment 1, a non-wounded, non-inoculated control, are presented in tabular form since incidence of rot was so low that suitable graphs could not be prepared. Even at the high levels of radiation (15 kilorep) incidence of rot in Sebago was negligible (Table 1) except in the trial lot radiated in April and stored 90 days and in the trial lot radiated in July. Inhibition of sprouting in all these trials was usually complete in the 12.5 and 15 kilorep levels with the Sebago variety. Inhibition of sprouting was partial at irradiation levels of 5 and 7.5 kilorep. Progression of rot in potatoes stored at 40° F. was extremely slow and for that reason, only 1 trial at this temperature was undertaken.

Incidence of rot with Red Pontiac, Katahdin, and Idaho Russet potatoes was low in the control tubers which were neither wounded nor inoculated (Table 2). It should be pointed out, however, that the samples under observation were of necessity, rather small. At the 90-day storage period, the Russet Burbank variety was breaking down to almost the same extent in all treatments.

TABLE 1

Rot incidence in nonwounded, noninoculated control Sebago tubers in each trial

Variety Storage temperature Days in storage	Replication and date irradiated	Irradiation dosage											
		0 kilorep		5.0 kilorep		7.5 kilorep		10.0 kilorep		12.5 kilorep		15.0 kilorep	
		Tubers	Rot	Tubers	Rot	Tubers	Rot	Tubers	Rot	Tubers	Rot	Tubers	Rot
		Total no.	%	*Total no.*	%	*Total no.*	%	*Total no.*	%	*Total no.*	%	*Total no.*	%
Sebago 60–70° F. 30 days	A, 1/8/57	35	6	39	8	40	0	37	5	36	3	39	0
	B, 1/22/57	37	0	37	0	36	3	36	0	39	0	36	0
	C, 2/5/57	37	3	40	0	38	0	36	0	37	0	33	0
	Average		3		3		0.9		2		0.9		0
Sebago 60–70° F. 90 days	A, 1/8/57	35	6	39	8	40	0	37	5	36	3	39	0
	B, 1/22/57	37	3	37	0	36	3	36	0	39	0	36	0
	C, 2/5/57	37	8	40	0	38	0	36	0	37	8	33	0
	Average		4		3		0.9		2		4		0
Sebago 60–70° F. 30 days	A, 4/4/57	38	0	40	0	36	0	37	5	35	8	37	11
	B, 4/16/57	40	0	41	0	37	0	34	3	35	0	37	5
	Average		0		0		0		4		4		8
Sebago 60–70° F. 90 days	A, 4/4/57	38	5	40	10	36	17	37	13	35	14	37	18
	B, 4/16/57	40	5	41	32	37	46	34	41	35	66	37	30
	Average		5		21		32		30		40		24
Sebago 60–70° F. 30 days	A, 7/3/57	41	7	43	24	38	10	40	15	37	14	32	38
	B, 7/3/57	42	9	41	12	38	26	37	19	42	14	37	40
	Average		8		18		18		17		14		39
Sebago 40° F 100–190 days	A, 1/8/57	38	0	35	3	37	0	38	5	37	8	36	3
	B, 1/22/57	38	0	39	0	38	3	34	3	39	5	39	5
	C, 2/5/57	33	0	42	2	38	3	38	3	35	6	37	11
	D, 3/5/57	35	0	35	0	34	0	35	6	38	3	39	0
	Average		0		1		1		4		5		5

TABLE 2

Rot incidence in nonwounded, noninoculated control tubers in each trial

Variety Storage temperature Days in storage	Replication and date irradiated	Irradiation dosage							
		0 kilorep		5.0 kilorep		10.0 kilorep		15.0 kilorep	
		Tubers	Rot	Tubers	Rot	Tubers	Rot	Tubers	Rot
		Total no.	%	*Total no.*	%	*Total no.*	%	*Total no.*	%
Russet Burbank 60–70° F. 30 days	A, 4/16/57	17	0	27	4	23	0	26	0
	B, 4/18/57	23	9	22	0	22	0	24	8
	C, 4/25/57	34	0	26	0	24	0	28	0
	Average		3		1		0		3
Russet Burbank 60–70° F. 90 days	A, 4/16/57	17	0	27	11	23	13	26	23
	B, 4/18/57	23	48	22	9	22	18	24	13
	C, 4/25/57	34	6	26	19	24	21	28	22
	Average		18		13		17		19
Katahdin 60–70° F. 30 days	A, 4/25/57	19	0	24	0	18	0	25	0
	B, 4/30/57	21	0	25	0	20	0	32	0
	C, 5/7/57	24	0	24	0	20	0	29	0
	Average		0		0		0		0
Katahdin 60–70° F. 30 days	A, 4/25/57	19	0	24	4	18	6	25	0
	B, 4/30/57	21	0	25	0	20	0	32	6
	C, 5/7/57	24	0	24	0	20	5	29	3
	Average		0		1		4		3
Red Pontiac 60–70° F. 30 days	A, 4/18/57	14	0	20	0	23	0	18	0
	B, 4/30/57	19	0	15	0	15	0	17	0
	C, 5/7/57	24	0	20	0	25	0	25	0
	Average		0		0		0		0
Red Pontiac 60–70° F. 90 days	A, 4/18/57	14	7	20	15	23	17	18	11
	B, 4/30/57	19	5	15	73	15	40	17	35
	C, 5/7/57	24	8	20	45	25	40	25	92
	Average		7		42		33		46

In order to establish uniform infection, tubers were wounded in a manner previously described. Non-inoculated controls were wounded in an identical manner. Sebago controls (Fig. 1) wounded prior to irradiation (C-1) were compared with those wounded after irradiation (C-2). In practically every trial, the incidence of rot was somewhat higher in controls which had been wounded just before radiation (C-1) than in those wounded following radiation (C-2). The same general trend followed inoculation with rot inciting organisms (Figs. 1 and 2). Rot incidence was higher where tubers were wounded and inoculated prior to radiation (C-1 or I-1) than where wounding and inoculation followed radiation (C-2 and I-2). The exact reason for this is not clearly understood although the results with Sebago were similar with either of the 2 rot producing organisms and in the controls.

Incidence of rot in wounded noninoculated Sebago tubers was generally lowest when tubers were radiated during the middle of the storage period, January and February (Fig. 1, A and B, C-1 and C-2). It was somewhat higher with tubers radiated in April which is near the end of the normal storage period (Fig. 1, C and D), and was highest where tubers were radiated past the normal storage period in July (Fig. 1, E). Data for the 90-day observation following June radiation could not be obtained because of the extensive rot developing prior to the 30-day period.

Incidence of bacterial soft rot in the January inoculation trial with Sebago was not appreciably higher than that in the noninoculated controls (Fig. 1, A, B, and F). These inoculations were made with a culture which had been tested only in a preliminary manner and the inoculum had been diluted 1–10 for this work. Later inoculation trials (Fig. 1, C, D, and E) were prepared with more virulent cultures of the soft rot organism and the inoculum was diluted 1–5 before inoculation. Under these conditions the incidence of rot following inoculation was somewhat higher than that occurring in the noninoculated controls.

Rot of Sebago following inoculation with *F. sambucinum* was considerably more severe than that in the noninoculated controls. Incidence of rot was progressively increased as irradiation intensity was increased. In these tests, the culture of *F. sambucinum* was generally more pathogenic than the culture of *E. carotovora*.

A reversal of the trend observed in Sebago was obtained with Maine grown Katahdin in the wounded, noninoculated controls. Rot was more severe in the control tubers wounded after radiation (C-2) than in the tubers wounded before radiation (C-1) (Fig. 3, A and B; Fig. 4, A and B). Rot following inoculation of Katahdin with either *E. carotovora* or *F. sambucinum* was again more severe when tubers were inoculated after radiation (I-2) than when tubers were inoculated before radiation (I-1) (Fig. 3, A and B; Fig. 4, A and B). The noninoculated Idaho grown Russet Burbank tubers responded in these trials in a manner similar to the noninoculated Katahdins (Fig. 3, C and D; Fig. 4, C and D). Rot following inoculation of this variety was more severe in tubers inoculated after radiation than in tubers inoculated before radiation.

Incidence of rot in the Red River valley grown Red Pontiac tubers was so low at the 30 day reading that no trends were apparent (Fig. 3, E; and Fig. 4, E). At the 90 day observation, rot in noninoculated controls (Fig. 3, F; and Fig. 4, F) was more severe when wounding followed radiation than when wounding preceded radiation. Rot in tubers inoculated with either pathogen was generally lower when tubers were inoculated following radiation (I-2) than when tubers were inoculated before radiation (I-1).

Incidence of rot with noninoculated controls was progressively increased in each of the 4 varieties under test as radiation intensity was increased. Even though this increase was generally slight it was consistent over the range of conditions employed.

Inoculation of Katahdin, Russet Burbank, and Red Pontiac (Fig. 3) with bacterial soft rot was accomplished with the same cultures and under the same conditions as those used on Sebago (Fig. 1, C and D). Incidence of bacterial soft rot following inoculation was usually higher than that in the noninoculated controls and followed the same general pattern as that in Sebago.

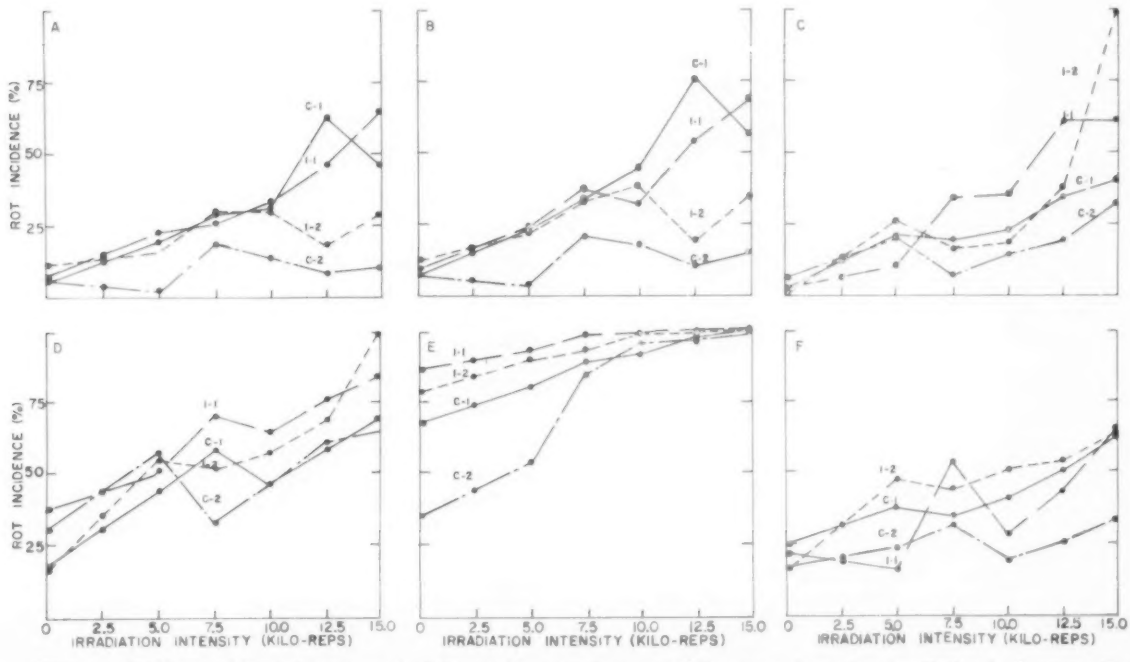


Figure 1. Incidence of bacterial soft rot in Sebago tubers stored at 60–70° F.: A, 30 days after irradiation in January; B, 90 days after irradiation in January; C, 30 days after irradiation in April; D, 90 days after irradiation in April; E, 30 days after irradiation in July; and F, stored at 40° F. for 150 days after irradiation in January. Legend: C-1, control wounded before irradiation; C-2, control wounded after irradiation; I-1, inoculation before irradiation; and I-2, inoculation after irradiation.

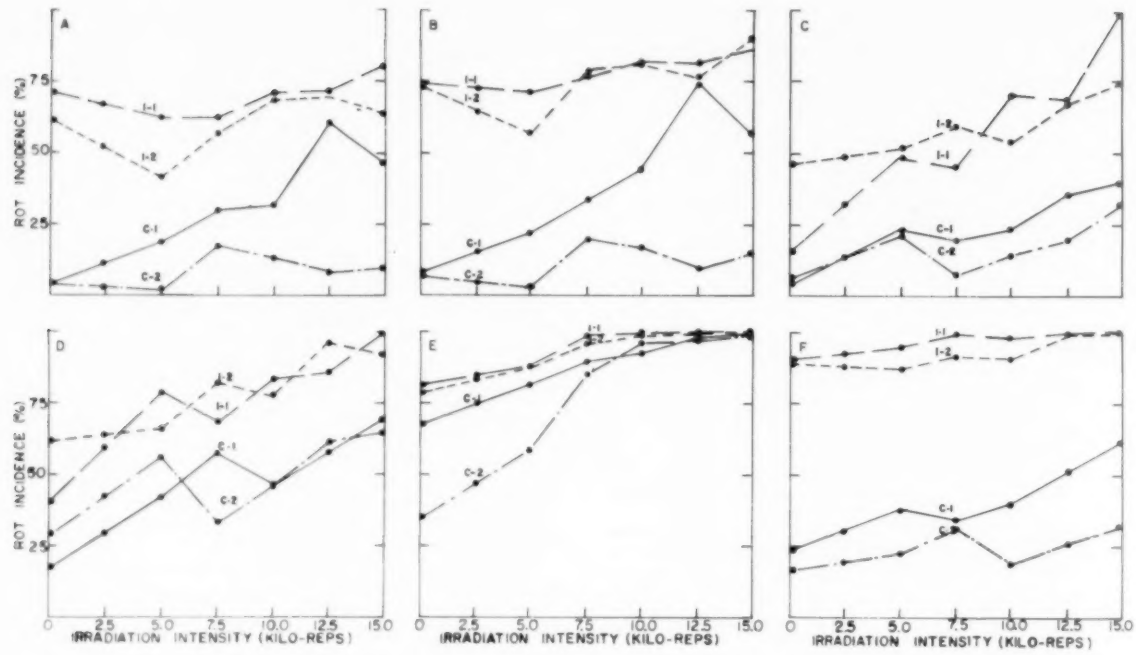


Figure 2. Incidence of Fusarium sambucinum rot in Sebago tubers stored at 60–70° F.: A, 30 days after irradiation in January; B, 90 days after irradiation in January; C, 30 days after irradiation in April; D, 90 days after irradiation in April; E, 30 days after irradiation in July; and F, stored at 40° F. for 150 days after irradiation in January. Legend: C-1, control wounded before irradiation; C-2, control wounded after irradiation; I-1, inoculation before irradiation; I-2, inoculation after irradiation.

Incidence of bacterial soft rot was essentially similar to Sebago in the Maine grown Katahdin variety radiated in April and observed at either the 30 or 90 day intervals (Fig. 3, A and B). It was somewhat higher than Sebago in the case of Idaho grown Russet Burbanks (Fig. 3, C and D) and noticeably lower than Sebago in the case of the Red Pontiacs at the 30-day period. At the end of 90 days the incidence of rot in Red Pontiac tubers was considerably higher than at the 30 day period. Increased radiation intensity was consistently associated with increased incidence of tuber rot in each of the varieties following inoculation with *E. carotovora* (Fig. 1, and Fig. 3).

Incidence of Fusarium dry rot in Sebago (Fig. 2, C and D) was essentially similar to that in the Russet Burbank variety (Fig. 4, C and D). Rot incidence in Katahdin (Fig. 4, A and B) was only slightly less than that occurring in the previous 2 varieties but more than that occurring in Red Pontiac (Fig. 4, E) at the 30-day observation. Rot incidence in Red Pontiac was considerably higher at the 90 day observation (Fig. 4, F) than at the 30-day period.

The greatest differences between any inoculation treatments and the controls were obtained at low temperature storage (Fig. 3, F) with *F. sambucinum*.

The extent of spread of rot through tissues of all infected tubers was determined by measuring from the point of inoculation to the margin of the lesion. At these low levels of radiation there were no consistent differences in rate or extent of spread of rot through tuber tissue. Furthermore in this respect there were no differences between any level of radiation and the non-irradiated tubers. Although rot incidence was higher following radiation there was no evidence that the inherent susceptibility of the tuber tissues had been modified by radiation, and that the rate of progression through the tuber had been modified. These observations are in contrast to those previously reported *(3)* in which high levels of irradiation considerably in excess of those used in these trials impared tuber tissue resistance.

DISCUSSION

In the report of Sparrow and Christensen *(6)* there is no indication that storage rots developed in their trials following ionizing irradiation. The importance of storage rots in tubers exposed to ionizing irradiation has been emphasized by Heiligman *(2)*, Schreiber and Highlands *(5)*, and Hooker and Duncan *(3)*. Mukhin and Panasenko *(4)* report inoculation studies on radiated tubers infected with *Phytophthora infestans*. They noted increased infection if inoculation followed radiation over that if inoculation preceded radiation.

The effect of gamma irradiation at levels of 15 kilorep and below on rots of potato tubers in storage was evaluated in relatively large lots of tubers. Wounded tubers developed appreciably more storage rot than did nonwounded tubers suggesting that careful handling before and after radiation is important in avoiding losses. Rot was gradually increased with increasing intensity of radiation suggesting that there is no well defined level below which rot is not a factor and above which rot develops rapidly. Storage rot was generally highest at the 10–15 kilorep dosage suggesting that at levels which inhibited sprouting susceptibility may have been enhanced.

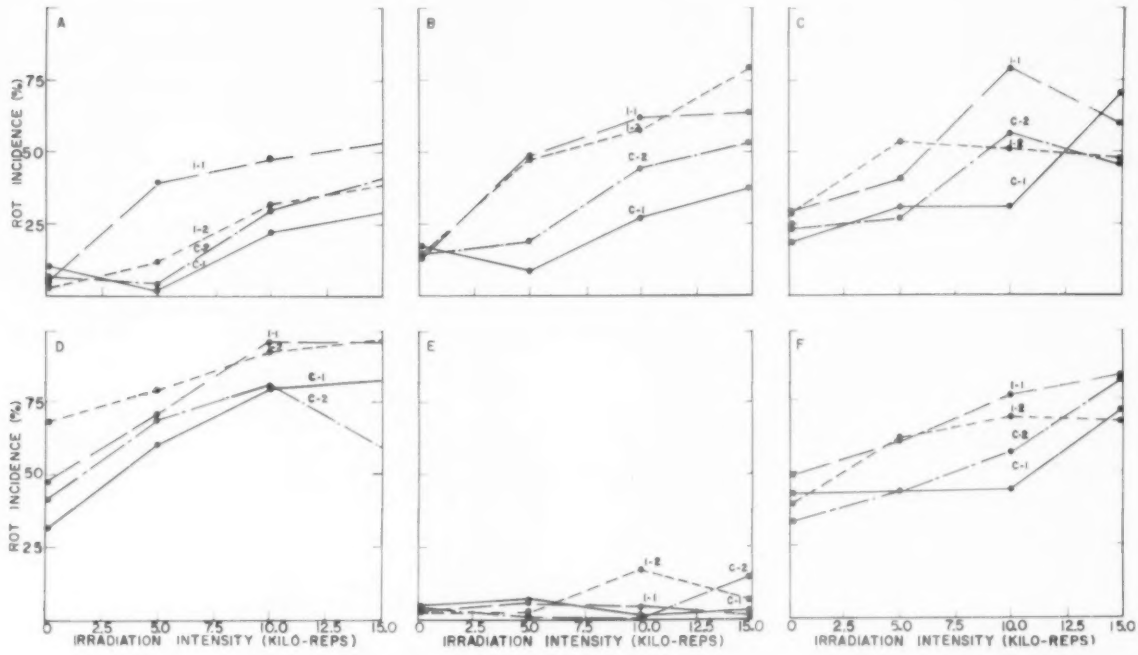


Figure 3. Incidence of bacterial soft rot in tubers irradiated in April and stored at 60–70° F. Maine grown Katahdin stored, A, 30 days and, B, 90 days. Idaho grown Russet Burbank stored, C, 30 days and, D, 90 days. Red River Valley Pontiacs stored, E, 30 days and, F, 90 days. Legend: C-1, control wounded before irradiation; C-2, control wounded after irradiation; I-1, inoculation before irradiation; I-2, inoculation after irradiation.

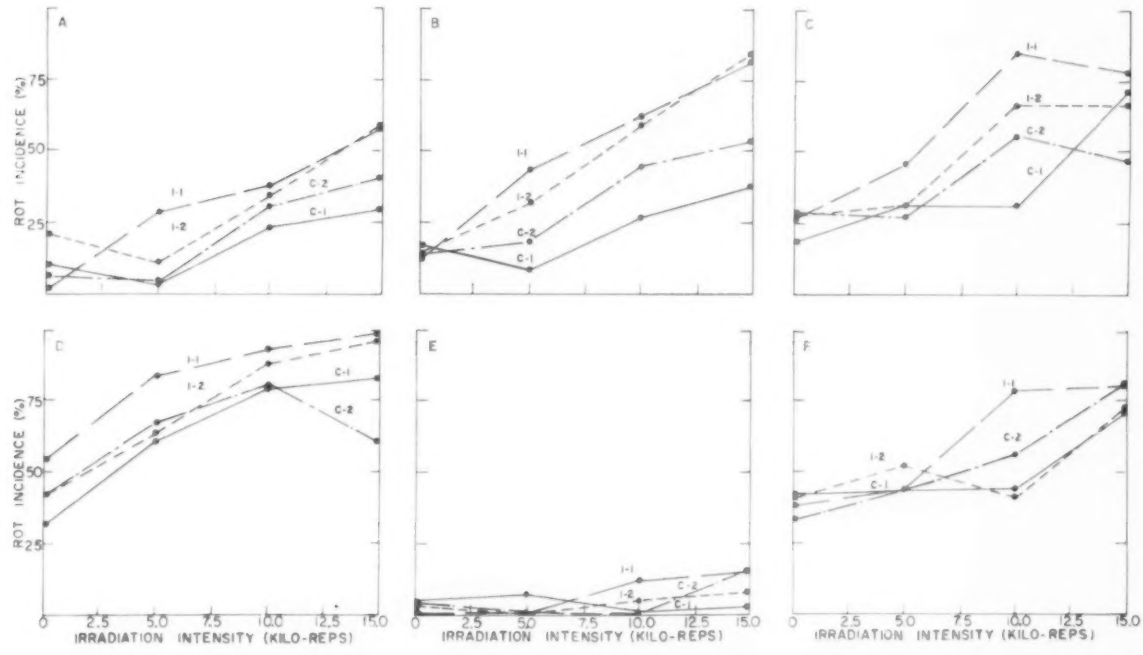


Figure 4. Incidence of Fusarium sambucinum rot in tubers irradiated in April and stored at 60–70° F. Maine grown Katahdin stored, A, 30 days and, B, 90 days. Idaho grown Russet Burbank stored, C, 30 days and, D, 90 days. Red River Valley Pontiacs stored, E, 30 days and, F, 90 days. Legend: C-1, control wounded before irradiation; C-2, control wounded after irradiation; I-1, inoculation before irradiation; I-2, inoculation after irradiation.

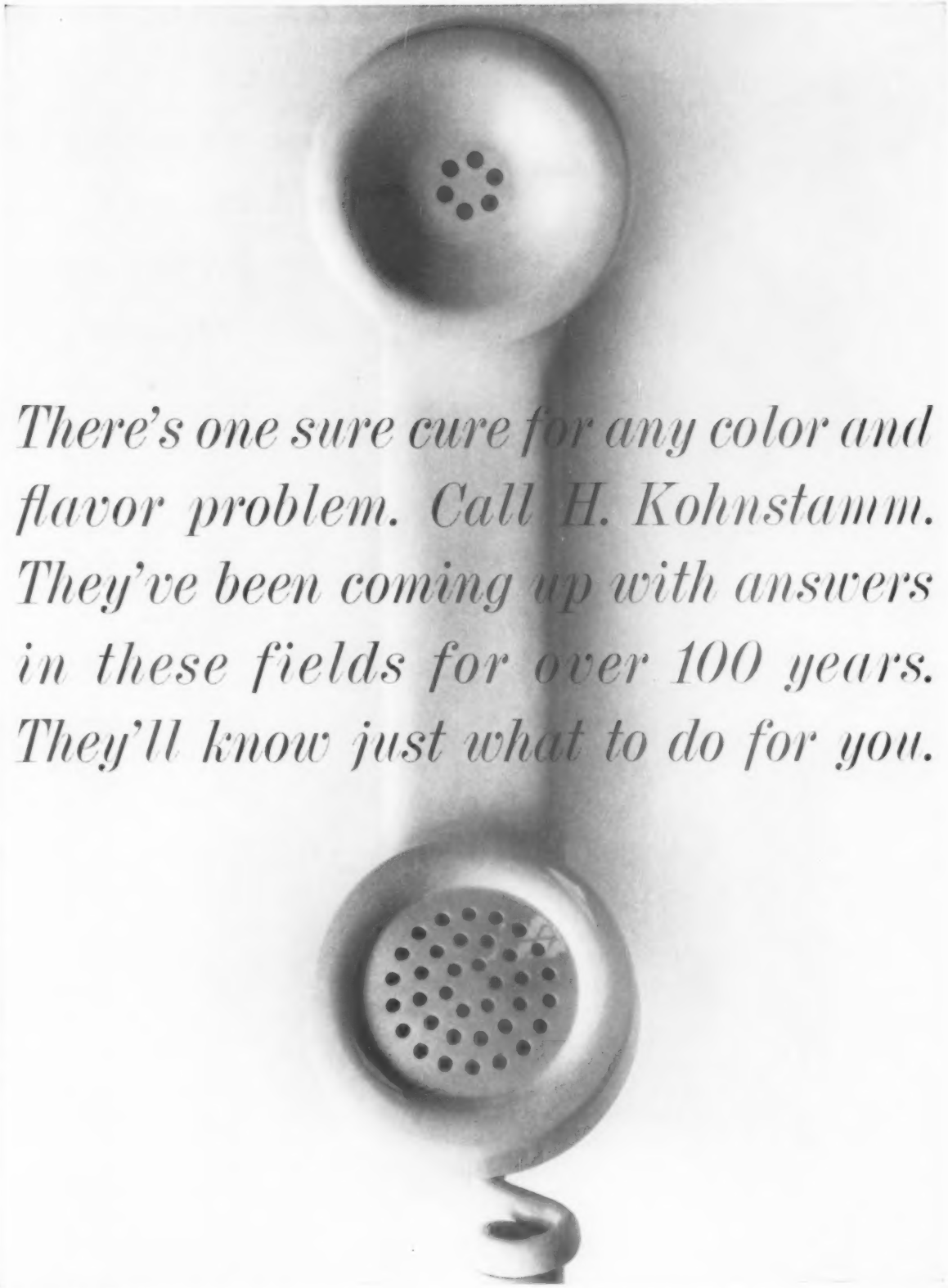
SUMMARY

Storage rot incidence of potato tubers following exposure to ionizing irradiation was determined with relatively large lots of tubers at low levels (2.5 to 15.0 kilorep) of intensity. Nonwounded, noninoculated tubers developed little storage rot at these levels of irradiation and at the 10–15 kilorep intensities sprouting was inhibited. Wounding of tubers before or after irradiation increased incidence of rot over nonwounded tubers. Incidence of storage rot in wounded, noninoculated tubers was highest at the high levels of irradiation intensity.

Inoculation with either *Fusarium sambucinum* Fuck. form 6 Wr. or *Erwinia carotovora* (L. R. Jones) Holland increased incidence of rot. Rot incidence of wounded, inoculated tubers was progressively increased as irradiation intensity was increased. At these low levels of irradiation, rate of rot progression through tuber tissue could not be correlated with irradiation intensity. Rot following inoculation with *F. sambucinum* f. 6 was consistently more severe when inoculation followed irradiation than when inoculation preceded irradiation. A similar but less distinct trend was obtained with *E. carotovora*. Indiana grown Sebago tubers developed consistently more rot when wounded or wounded and inoculated after irradiation than when wounded before irradiation. With the other tuber lots there was no consistent relationship between rot incidence and time of wounding.

LITERATURE CITED

1. Ayers, G. W., and Robinson, D. B. An inoculation technique for the study of dry rot of potatoes. *Am. Potato J.* **31**, 278–281 (1954).
2. Heiligman, F. Effects of ionizing radiation on white potatoes. *Am. Potato J.*, **34**, 153–157 (1957).
3. Hooker, W. J., and Duncan, D. T. Storage rot susceptibility of potato tubers exposed to ionizing irradiation. *Am. Potato J.* (in press). (1959).
4. Mukhin, E. N., and Panasenko, N. P. Effects of Co^{60} irradiation on susceptibilty of potato tubers to microorganisms. Doklady Akademy Nauk SSSR 115: 1209. Translation published by the American Institute of Biological Science 115: 162–165 (1957).
5. Schreiber, J. S., and Highlands, M. E. A report on the commercial storage of irradiated white potatoes. *Maine Farm Research*, **5** (4) Jan. 19–22 (1958).
6. Sparrow, A. H., and Christensen, E. Improved storage quality of potato tubers after exposure to Cobalt-60 gamma. *Nucleonics*, **12**, 16–17 (1954).



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Effect of Packaging on Palatability and Weight Loss of Frozen Ground Pork and Beef[a,b]

(Manuscript received June 6, 1958)

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PREVIOUS EXPERIMENTS in this laboratory and elsewhere *(2, 4, 7)* have shown that the palatability and general acceptability of certain frozen foods in storage may be significantly affected by the type of packaging material used.

It is commonly believed that the oxidation of fats is primarily responsible for the flavor changes that occur in many foods during storage at temperatures below their freezing points. Wills, Lowe, Slosberg, and Stewart *(6)* and others have found appreciable losses in the oxygen content of sealed metal containers in which meat has been stored at freezing temperatures, even as low as −35° F. (−37.2° C.). Privett *(3)*, working with frozen pork, beef, lamb, and turkey, found that the oxidation of fats is almost entirely limited to the exposed surfaces of the meat.

The present study was continued over a period of three years using ground pork and ground beef processed in 1954 and 1955. It was designed to evaluate the effect on palatability of the stored frozen product resulting from:

(a) packaging in an initial atmosphere of nitrogen
(b) treating packaging films with antioxidants
(c) using different gauges of polyethylene for packaging
(d) using polyethylene in combination with other materials for packaging

In addition, data on weight loss during storage were obtained with the ground meat processed in 1954. An exploratory study also was made to determine whether the addition of ferric chloride to the meat would accelerate changes in palatability which might make it possible to shorten the period of time required for a packaging study.

Storage temperatures above the recommended range 0° F. (−17.78° C.) or lower were used in order to shorten the period required for taste panel evaluation. Therefore, the results indicate differences, if any, among the packaging materials but do not necessarily indicate the storage life of the product at recommended storage temperatures.

MATERIALS AND METHODS

Ground pork and beef. The pork was ground from two carefully selected carcasses, utilizing 4 hams, 2 shoulders, and 2 loins. Grinding and packaging was completed within 2 days after slaughter in 1954 and within 4 days in 1955.

The beef was ground from a front quarter, grade U. S. Good, after the carcass was chilled and aged at approximately 34° to 36° F. (1.11° to 2.22° F.) for 3 days in 1954 and for 5 to 6 days in 1955. The meat was ground once, mixed thoroughly by hand, then ground again. No salt or seasoning was added.

Ferric chloride was added to one lot each of beef and pork in 1954 to determine whether the concentration used would act as a pro-oxidant to accelerate changes in palatability. A small amount, 0.03 g., was dissolved in 5 cc. of water and mixed with 3,000 g. of meat, thus adding about 10 p.p.m. of ferric chloride.

Packaging materials. The following materials were used, all in bag form except the aluminum foil:

(a) Polyethylene 0.0015 in., 0.002 in., 0.0025 in., 0.003 in., 0.005 in. and 0.01 in.
(b) 300 MSAT cellophane coated with 0.0015 in. polyethylene
(c) Cellophane laminated to polyethylene (Flex-Vac 190 A)
(d) Aluminum foil 0.00035 in. coated with polyethylene 0.0015 in.
(e) Polyethylene 0.0015 in. outside coated with polyvinyl alcohol 0.0005 in.–0.001 in.
(f) Aluminum locker foil 0.0015 in.

Antioxidant treatments. The antioxidant treatment used in 1954 consisted of preparing a 5% solution, by weight, of Tenox II in absolute isopropanol and pouring 20 ml. into each bag to be treated. The solution was worked by hand on a flat surface to wet the entire inside area of the bag. Excess solution was drained, and the bags were drained in nitrogen. All treated and dried bags were vacuum packed in polyethylene until used.

In 1955, antioxidants were incorporated in the polyethylene resin under the following codes:

Resin Code	*Composition*
A	0.02% DBPC and 0.03% Armid O
B	0.1% BHA

Packaging methods. Approximately 180 g. of ground meat were placed in each bag. Excess air was evacuated in the following manner from certain lots as indicated in Tables 1–5, by means of a vacuum pump capable of producing a vacuum of 0.0003 mm. of mercury. The bag was heat-sealed about 3 inches above the product. A second seal, short by about one inch, was made about 2 inches above the product, providing a channel between seals into which ⅛ inch stainless steel tube from the vacuum pump was inserted. After evacuation of the air for 10 to 20 seconds the steel tube was partially withdrawn and a cross-seal was made. The heat seal was made by a Thermal Impulse Heat sealer. A label identification was inserted and sealed in the excess length of the bag above the previously described seals. The samples in aluminum foil were packaged by the customary "freezer wrap" method.

Packaging in nitrogen, as indicated in Tables 1–2, was accomplished by first forming a seal extending three-quarters across the bag at about 3 inches above the meat sample. A stainless steel tube leading from a cylinder of nitrogen was inserted to the bottom of the bag and a free flow of nitrogen gas was allowed to pass into the bag for about 30 seconds. Then the tube was withdrawn and the bag was collapsed by hand smoothing, and quickly sealed.

Processing dates. Ground pork was packaged and frozen on January 20, 1954, and on March 7, 1955. Ground beef was packaged and frozen on March 23, 1954, and on March 23, 1955.

[a] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, May 28, 1958.

[b] Paper No. 3942 of the Sicentific Journal Series of the Minnesota Agricultural Experiment Station. This study was partially financed by a grant from the Bakelite Co., Division of Union Carbide Corporation.

TABLE 1

Palatability scores and weight loss of ground pork during storage at 8° to 12° F. (−13.33° to −11.11° C.) when sealed in different atmospheres at time of packaging

Lot	Year packed	Packaging material	Packaging method	Storage period	Palatability scores[1]	Average weight loss[2]
				months	*average*	%
B	1954	Polyethylene 0.0025 in., inside treated with Tenox II	In nitrogen; heat sealed	4	8.0	0.06 (gain)
				6	5.9	0.03 (gain)
				11	4.5	0.03
C	1954	Polyethylene 0.0025 in., inside treated with Tenox II	Air, not evacuated; heat sealed	4	7.6	0.07
				6	6.8	0.00
				11	5.1	0.01 (gain)
H	1954	Reference sample stored in aluminum foil 0.0015 in. at −15° F. (−26.11° C.)	Air, not evacuated; freezer wrap	4	8.8	0.04
				6	9.0	0.47
				11	6.8	0.10
					5% level	1% level
L.S.D. between packaging materials (Lots B and C) 6 months, palatability scores					.....	.7720

[1] Scoring range 1 to 10, with 10 the optimum. A score of approximately 7.0 or higher indicates a rating of good or better. Score of the fresh sample was 8.6.

[2] All weighings included the weight of the packaging material.

TABLE 2

Palatability scores and weight loss of ground beef during storage at 8° to 12° F. (−13.33° to −11.11° C.) when sealed in different atmospheres at time of packaging

Lot	Year packed	Packaging material	Packaging method	Storage period	Palatability scores[1]	Average weight loss[2]
				months	*average*	%
A	1954	Polyethylene 0.0025 in.	Excess air evacuated; heat sealed	6½	5.7	0.02
				10	5.1	0.01
B	1954	Polyethylene 0.0025 in.	In nitrogen; heat sealed	6½	5.8	0.02
				10	5.3	0.00
C	1954	Polyethylene 0.0025 in.	Air, not evacuated; heat sealed	6½	4.8	0.20 (gain)
				10	5.3	0.05 (gain)
E	1954	300 MSAT cellophane coated with polyethylene 0.00175 in.	In nitrogen; heat sealed	6½	6.2	0.08 (gain)
				10	6.3	0.14 (gain)
F	1954	Cellophane laminated to polyethylene (Flex-Vac 190 A)	In nitrogen; heat sealed	6½	6.0	0.11 (gain)
				10	5.7	0.10 (gain)
H	1954	Reference sample stored in aluminum foil 0.0015 in. at −15° F. (−26.11° C.)	Air, not evacuated; freezer wrap	6½	8.3	0.09 (gain)
				10	7.3	0.16
					5% level	1% level
L.S.D. between packaging materials (Lots A, B, and C) 6½ months, palatability scores					.8430	1.1212

[1] Scoring range 1 to 10, with 10 the optimum. A score of approximately 7.0 or higher indicates a rating of good or better. Score of the fresh sample was 8.8.

[2] All weighings included the weight of the packaging material.

Freezing. All of the packages, including the reference samples were placed one layer deep on the refrigerated shelves of one of several upright type home freezers operating so that all samples were placed in a freezer within 10 to 15 minutes after packaging.

Storage. All samples except the reference samples were stored in a large commercial low temperature room for the periods indicated in Tables 1–5. All samples of each product were placed on one wooden shelf, one layer deep, with a space of about one inch between the packages. A Bristol recording thermometer was used to determine the storage temperature which was found to fluctuate between about 8° to 12° F. (−13.33° to −11.11° C.).

The reference samples in .0015 in. aluminum foil were stored at approximately −15° F. (−26.11° C.).

Taste panel. Samples for tasting were broiled in an electric oven under uniform cooking conditions. A numbered aluminum tag was inserted in the top of each sample for identification purposes, and the same code was marked on the plates used when judging.

A reference sample from the same original lot, but stored at approximately −15° F. (−26.11° C.), was used at each judging. The panel of 5 experienced and qualified judges first agreed on an acceptable score for the reference sample, then individually scored the remaining samples. This technique provided each judge with a uniform basis of comparison from one judging period to another. The maximum number of samples judged at one time was six, in addition to the reference sample. The taste panel members were the same throughout all the judgings for each experiment.

Weight records. All weighings were done at the prevailing storage temperature, on a laboratory balance held in the storage room for that purpose. Some slight gains in weight were recorded, apparently due to unavoidable moisture condensation on the package. All weighings included the weight of the packaging material.

Analysis of data. Four replicate samples were used for each treatment and storage period. A statistical analysis was made of the taste panel scores to determine the significance of differences, except for the reference samples which were not scored individually.

RESULTS

The palatability scores for ground pork and beef packaged in initial atmospheres of nitrogen and air, with and without evacuation of the excess air inside the bags, are shown in Tables 1 and 2. At about 6 months the scores for pork packaged in nitrogen were significantly lower than for comparable samples packaged in air without evacuation of the excess air, but the opposite results were found with beef. There were no

TABLE 3

Palatability scores of ground pork packaged in polyethylene films with and without antioxidant treatment when stored at 8° to 12° F. (−13.33° to −11.11° C.)

Lot	Year packed	Thickness of film	Packaging method heat sealed	Storage period	Antioxidant treatment packaging	Palatability scores[1]
				months		*average*
A	1954	0.0025 in.	Excess air evacuated	4	None	8.1
				6		7.2
				11		5.3
C	1954	0.0025 in.	Excess air not evacuated	4	Inside treated with Tenox II	7.6
				6		6.8
				11		5.1
A-1	1955	0.0015 in.	Excess air evacuated	7	None	5.50
				10½	None	5.40
H-1	1955	0.0015 in.	Excess air evacuated	7	Code A	5.95
				10½	Code A	4.90
M-1	1955	0.0015 in.	Excess air evacuated	7	Code B	4.90
				10½	Code B	5.45
J-1	1955	0.002 in.	Excess air evacuated	7	Code A	6.25
				10½	Code A	5.30
B-1	1955	0.0025 in.	Excess air evacuated	7	None	5.80
				10½	None	5.50
K-1	1955	0.003 in.	Excess air evacuated	7	Code A	5.80
				10½	Code A	5.02
C-1	1955	0.005 in.	Excess air evacuated	7	None	6.55
				10½	None	5.25
D-1	1955	0.01 in.	Excess air not evacuated	7	None	5.80
				10½	None	5.50

[1] Scoring range 1 to 10, with 10 the optimum. A score of approximately 7.0 or higher indicates a rating if good or better. Score of the fresh sample was 8.6 in 1954 and 9.6 in 1955.

TABLE 4

Palatability scores of ground pork packaged in different gauges of polyethylene film and in aluminum locker foil when stored at 8° to 12° F. (−13.33° to −11.11° C.)

Lot	Year packed	Packaging material and thickness	Packaging method	Storage period	Palatability scores[1]
				months	*average*
A-1	1955	Polyethylene 0.0015 in.	Heat sealed, excess air evacuated	7	5.50
				10½	5.40
B-1	1955	Polyethylene 0.0025 in.	Heat sealed, excess air evacuated	7	5.80
				10½	5.50
C-1	1955	Polyethylene 0.005 in.	Heat sealed, excess air evacuated	7	6.55
				10½	5.25
D-1	1955	Polyethylene 0.01 in.	Heat sealed, excess air not evacuated	7	5.80
				10½	5.50
R-1	1955	Aluminum foil 0.0015 in.	Freezer wrap	7	7.25
				10½	5.75
S-1	1955	Reference sample stored in aluminum foil 0.0015 in. at −15° F. (−26.11° C.)	Freezer wrap	7	9.00
				10½	7.00
				5% level	1% level
L.S.D. (Lots A-1, B-1, C-1, D-1, R-1) 7 months				.5780	.7624

[1] Scoring range 1 to 10, with 10 the optimum. A score of approximately 7.0 or higher indicates a rating of good or better. Score of the fresh sample was 9.6.

significant differences at any of the other storage periods with either pork or beef between samples packaged in initial atmospheres of nitrogen and air. The data do not indicate any advantage of packaging in an initial atmosphere of nitrogen with the plastic films used in this study. No data were obtained on the package atmosphere during storage.

There were no significant differences among the palatability scores for pork stored in packaging materials treated with antioxidants at the concentrations used and those stored in untreated materials, as shown in Table 3.

The palatability scores for ground pork packaged in different gauges of polyethylene film are shown in Table 4. At 7 months the scores for samples packaged in 0.005 in. film with excess air evacuated were significantly better at the 5% level than those for samples packaged in 0.0025 in. film, and significantly better at the 1% level than those for samples in 0.0015 in. film. However, much larger differences were found between the scores for samples packaged in 0.0015 in. aluminum foil and those packaged in polyethylene, the scores for the samples stored in aluminum foil being the highest. No significant differences were found after storage for 10½ months.

The palatability scores for ground pork packaged in four different gauges of polyethylene film and in polyethylene combined with (a) cellophane, (b) aluminum foil, and (c) a polyvinyl alcohol coating are shown in Table 5. At 7 months the palatability scores for the samples packaged in polyethylene in combination with other materials were significantly higher than those for samples packaged in the two lightest gauges of polyethylene, when air was evacuated from the packages before being heat sealed. The differences were relatively large and

TABLE 5

Palatability scores of ground pork packaged in polyethylene films and in films combining polyethylene with other materials when stored at 8° to 12° F. (−13.33° to −11.11° C.)

Lot	Year packed	Packaging material and thickness	Packaging method	Storage period	Palatability scores[1]
				months	*average*
A-1	1955	Polyethylene 0.0015 in.	Excess air evacuated; heat sealed	7	5.50
				10½	5.40
B-1	1955	Polyethylene 0.0025 in.	Excess air evacuated; heat sealed	7	5.80
				10½	5.50
C-1	1955	Polyethylene 0.005 in.	Excess air evacuated; heat sealed	7	6.55
				10½	5.25
D-1	1955	Polyethylene 0.01 in.	Excess air not evacuated; heat sealed	7	5.80
				10½	5.40
E-1	1955	300 MSAT cellophane coated with 0.0015 in. polyethylene	Excess air evacuated; heat sealed	7	6.20
				10½	5.70
F-1	1955	Aluminum foil 0.00035 in. coated with polyethylene 0.0015 in.	Excess air evacuated; heat sealed	7	6.65
				10½	5.55
G-1	1955	Polyethylene 0.0015 in. outside coated with polyvinyl alcohol 0.0005 in.–0.001 in.	Excess air evacuated; heat sealed	7	6.60
				10½	5.25
S-1	1955	Reference sample stored in aluminum foil 0.0015 in. at −15° F. (−26.11° C.)	Excess air not evacuated; freezer wrap	7	9.00
				10½	7.00
				5% level	1% level
L.S.D. (Lots A-1, B-1, C-1, D-1, E-1, F-1, G-1), 7 months				.3749	.4945

[1] Scoring range 1 to 10, with 10 the optimum. A score of approximately 7.0 or higher indicates a rating of good or better. Score of the fresh sample was 9.6.

significant at the 1% level when comparison was made with the 0.0015 in. film. The differences were less, but significant at the 5% level, when a comparison was made with the 0.0025 in. film. There were no significant differences when a comparison was made with the 0.005 in. polyethylene film.

The palatability scores for the samples packaged in the heaviest gauge of polyethylene (0.01 in.) without evacuation of the air before being heat sealed were not significantly different at 7 months from those packaged in the two lightest gauges of polyethylene with air evacuated before being heat sealed.

There were no significant differences among any of the samples at 10½ months. No appreciable change in weight occurred in any of the lots during storage, as shown in Tables 1 and 2.

There was no significant effect on the palatability scores resulting from the addition of 10 p.p.m. of ferric chloride to ground beef and pork stored for 4 and 6 months at 8° to 120° F. (−13.33° to −11.11° C.). However, the scores for pork with ferric chloride added were significantly lower at the 1% level than for untreated samples after 11 months.

The experimental plan for 1955 included ground beef, using the same treatments as for pork. When this beef was sampled for the first time after storage for 8½ months, the palatability scores were unexpectedly low with no significant differences among them. These results are in agreement with all other data obtained in this study which show no significant differences when palatability scores are low.

DISCUSSION

Palatability scores for ground pork at the 4-month storage period in 1954 indicated that all samples remained good during this period regardless of the packaging material or treatment used. This indicates that the time factor is an important consideration in evaluating the relative merits of packaging materials for specific purposes.

Significant differences in the scores for pork were found at the 6 to 7 month period in 1954 and 1955. After storage of ground pork for 10½ months (1955) and ground beef for 6½ and 10 months (1954) at temperatures used in this study, all scores were low and significant differences were not found. However, it should be noted that scores of the reference samples stored at about −15° F. (−26.11° C.) remained relatively high, indicating the importance of storage temperature in retarding loss of palatability.

Watts *(5)* calls attention to inherent variations among different lots of meat in the rate at which oxidative deterioration occurs. Such "biological variation" may have as much influence as the packaging material on the rate at which palatability scores decrease during storage. The low scores for the ground beef stored for 8½ months may indicate the effect of such variation.

A considerable difference in the rate of oxygen permeability is known to exist among the packaging materials used, particularly at temperatures well above those used for storage of frozen foods. For example, at 73.4° F. (23° C.) the permeability rates of .0015 in. and .003 in. unmodified polyethylene films are reported to be approximately 330 and 160 ml./24 hrs./100 square inches *(1)*. It is possible that differences in palatability scores found in this study may be associated in some degree with these differences in oxygen permeability. The data given in Table 5 show that the lowest range of scores was associated with packaging materials having the higher rates of permeability to oxygen when excess air was evacuated before the container was heat sealed.

All the packaging materials used are known to have a low rate of permeability to water vapor. This is substantiated by the fact that in no case did an appreciable change in weight occur during storage. Therefore, the differences in palatability scores found in this study do not appear to be associated with dif-

ferences in water vapor permeability of the packaging materials.

SUMMARY

Ground pork and beef were packaged, frozen, and stored at 8° to 12° F. (−13.33° to −11.11° C.) for periods up to 11 months. Packaging materials used were polyethylene film of different gauges, polyethylene coated cellophane, laminated polyethylene-cellophane, polyethylene coated aluminum foil, polyethylene coated with polyvinyl alcohol, aluminum locker foil, and polyethylene film treated with antioxidants. Some lots were packaged in an initial atmosphere of nitrogen. All lots were judged for palatability and a statistical analyses of the data was made.

Palatability scores for pork at the 4-month storage period indicated that the palatability of all samples remained good during this period regardless of the packaging material or treatment used. Beef was not judged at this period.

Significantly higher palatability scores were found for pork stored 7 months in the heavier gauges of polyethylene than in the lighter gauges. Significantly higher scores also were found for pork stored 7 months in films made of polyethylene in combination with other materials than in film made of polyethylene alone. In both instances the differences in scores were not large.

After storage of ground pork for 10½ to 11 months and ground beef for 6½ and 10 months at the temperatures used in this study, all scores were low and significant differences were not found. The scores of the reference samples stored at about −15° F. (−26.11° C.) remained relatively high during these periods.

No advantage was indicated by packaging ground pork and beef in an initial atmosphere of nitrogen with the plastic films used in this study.

There were no significant differences in the palatability of ground pork attributable to treatment of the packaging materials with antioxidants at the concentrations used.

No appreciable change in weight of ground pork and beef occurred in any of the weighed lots during storage.

Since the storage temperature was considerably above those normally used, no conclusions regarding storage life of the product at recommended temperatures should be inferred.

Acknowledgments

The authors are indebted to Mrs. Carol B. Wilson, Mrs. Jean D. Parsons, Mrs. Joanne G. Kvasnicka and Miss Rebecca Wirt for assisting in the processing operation and in conducting of taste panel appraisals. Thanks are due also to Dr. Woodrow J. Aunan for his assistance in obtaining the meat; the Department of Animal Husbandry, University of Minnesota, for storing the low samples; Mrs. Gladys L. Olmsted for weighing the samples, and Mr. Chun Chien for making the statistical analysis.

LITERATURE CITED

1. Bakelite Company. A Division of Union Carbide and Carbon. Packaging Division Laboratories. Unpublished information.
2. McCoy, D. C. How wrappers influence the quality of frozen meat. *Food Inds.*, 19, 1497–98, 1613–15 (1947).
3. Privett, O. S., Pusch, F. J., and Lundberg, W. O. Fatty acid composition, and oxidative deterioration during storage, of fats in cuts of beef, lamb, pork, and turkey. *Food Technol.*, 9, 347–351 (1955).
4. Simpson, Jean I., and Chang, Irene C. L. Effect of low freezer storage temperature and wrapping material on the quality of frozen meats. *Food Technol.*, 8, 246–252 (1954).
5. Watts, Betty M. Oxidative rancidity and discoloration in meat. *Advances in Food Research*, 5, 1–52 (1954).
6. Wills, Rena, Lowe, Belle, Slosberg, H., and Stewardt, G. F. Frozen storage of poultry. *Refrig. Engin.*, 56, 49–51 (1948).
7. Winter, J. D., and Hustrulid, A. Flavor factors in frozen-food wraps. *Modern Packaging*, 24 (9), 133–37, 184, 186 (1951).

Color Values of California Wines*

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One of the most attractive features of wines is their color. It may be the light greenish yellow of a Riesling, the almost pure yellow of a dry sauterne or Semillon, the light amber yellow of a dry sherry, the moderate amber in a sweet sherry, the ruby-pink in a rosé, an almost pure red in a claret or burgundy, or an amber red in a tawny port. In each case the color pleases our aesthetic sense. In addition, the color indicates to the consumer something of the quality of the wine. An amber Riesling or dry sauterne is probably an oxidized high-aldehyde wine. An orange colored rosé indicates that the variety was improperly selected or that the wine has been aged too long. The slightest purple in a red wine shows us that the grapes were picked too late and that the pH is too high. Even by the most astute blending it is difficult to adjust the color so as to eliminate errors of production or aging.

Modern merchandising demands that food products be of a consistent color commensurate with a high quality product of each specific type. The wine quality standards of the Wine Institute *(19)* frequently specify a certain color for the different wine types. These are expressed in such unspecific terms as "darker-colored," "medium red," "lighter-colored," "deep red," etc. These suggested standards, as general as they are, demonstrate that the California wine industry recognizes the need for color standards for the important types of wines produced in this state.

The history of color standardization of wines was reviewed in the book of Dujardin-Salleron *(6)*. For the amber colored wines of Málaga and Jerez de la Frontera specially colored tubes were devised. A number of 19th century instruments are described. A bibliography of 19th century papers on the determination of the color of wines is significant in showing that the color of wine was of interest long before Young, Helmholtz, and other physicists of the period started their studies. As early as 1885 Salleron devised a "vino-colorimetre" which was designed to determine the nuances of color of red wines. Chevreul's studies of Gobelin tapestries were considered in the construction of the well-known Dujardin-Salleron vino-colorimeter. With all of its faults it did distinguish dominant wave length and brightness. For amber-colored wines Dujardin also designed a colorimeter especially so that by introducing water a color match was obtained. Since the water had a different pH than the wine and the wines differed in pH this was obviously a very defective system. The use of color standards, such as solutions of potassium permanganate or potassium dichromate, gave acceptable standards for wines of similar purity and dominant wave length, but failed when these two variables were not constant.

The first modern studies on color standards of wines based on the absorption curve for wines at different wave lengths were made in France by Boutaric *et al. (4)*. These studies suggested the optical density at 520 mμ and the ratio of the optical densities measured at 480 mμ and 640 mμ as measures of the visual color of red Burgundy wines. As Winkler and Amerine *(21)* and Mackinney and Chichester *(13)* point out there is no *a priori* reason why such a ratio may not characterize the color of a wine but only data on red table wines were presented in these studies and no evidence that such a ratio would distinguish various types of wines was obtained. In any case, the ratio would be most useful for red wines with similar transmission curves.

The first data in this country based on a sound modern basis were those of Winkler and Amerine *(21)* and Amerine and Winkler *(2)*. The trichromatic coefficients were determined for a variety of wines. The basic color characteristics of these wines were then calculated from these data. Their results were of little practical significance because of the limited number of types studied and because of their failure to standardize the depth at which their absorption curves were measured. This is because the color perceived with transmitted light changes with depth. The present study was designed to extend the data on color characteristics to a larger number of types and with more examples of each type in order to provide the wine industry with the basic data for possible future adoption of color standards for California wines.

While there are many sound economic reasons for standardizing the color standards for a given type of wine by a particular winery the standards for one producer may not be at all acceptable to another. Using color standards alone Amerine *(1)* has shown that the claret of one firm may be much darker or lighter (more or less red) than the burgundy of another firm. One important consideration for such competitive commercial types is that the differences be constant. There is considerable evidence that such color differences are not consistently maintained by individual companies. Furthermore, no large scale consumer preference studies seem to have been made to indicate what specific color (or colors) the public prefers for each of the standard competitive types.

For wines with a varietal and vintage appellations the problem becomes much more complex. Climatic differences lead to more or less pigmentation from one year to another (see Winkler and Amerine, *20*).

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, May 28, 1958.

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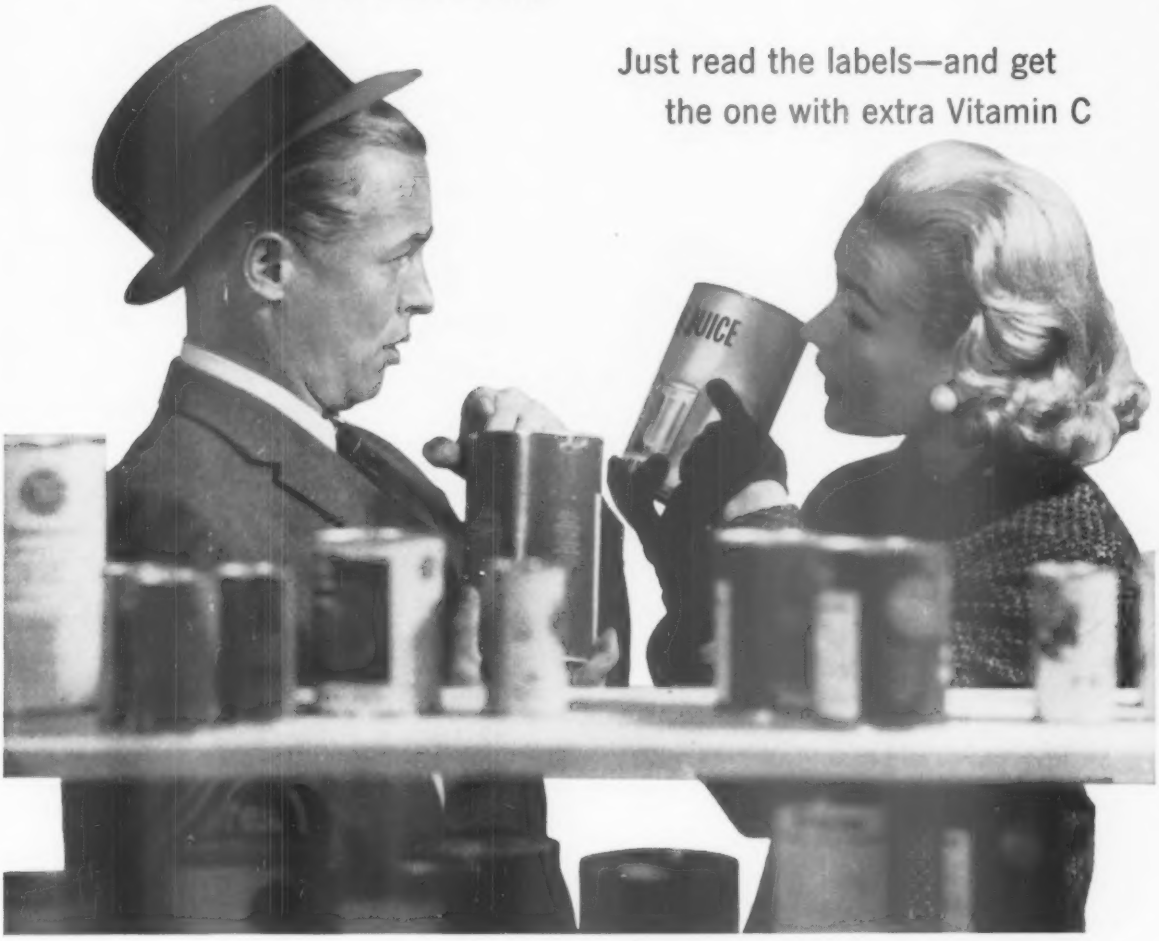

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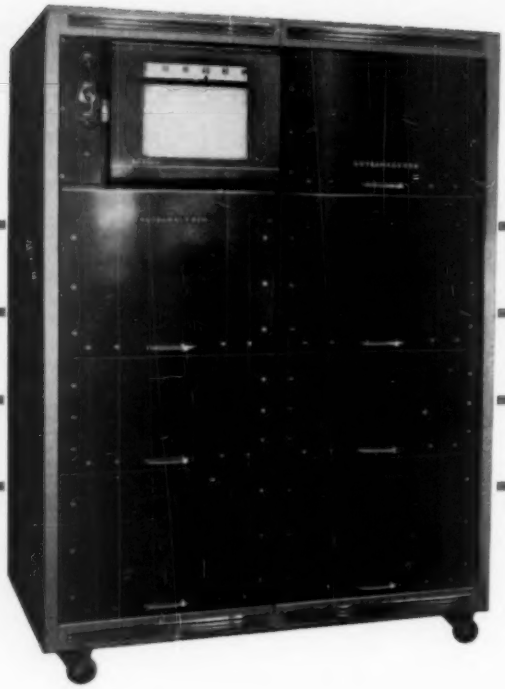

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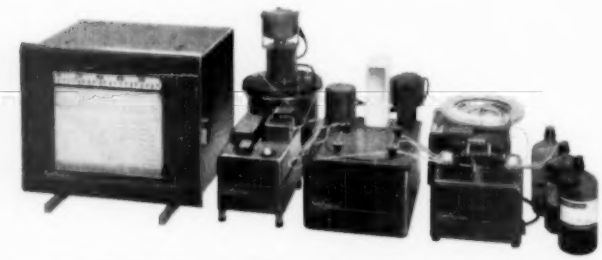

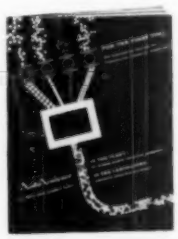

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Thus the wines of one vintage may be more or less colored than those of another vintage. These color differences in the case of connoisseurs may actually have sales appeal. Simon *(15)* indicates such a case with even such a highly standardized product as vintage champagne in France. At the turn of the century different brands of French Champagnes varied so much in color that the consumer could identify the vintage and even producer from the color.

With non-vintage wines of quality elaborate blending procedures may be employed to maintain the color standards of the standard types. The color plates of Gonzalez Gordon *(7)* and of the Instituto do Vinho do Pôrto *(9)*, for sherry and port, respectively, are examples of the industrial need for color standards for different sub-types of these wines in order to standardize the color of each of the sub-types.

This desire for uniformity of color within the type is also found in the beer industry. An editorial of the Wallerstein Laboratories *(18)* outlines the history of color standardization research in the beer industry. For American beers the problem is relatively simple because our beers are very pale and vary only slightly in spectrol characteristics. American brewers, therefore, have come to use a special color standard or filter photometers and spectrophotometers for defining the color intensity. Stone and Miller *(16)*, for example, define beer color as 10 times the optical density at 430 mμ in a one-half inch cell. Quite good checks using four different Beckman quartz spectrophotometers were obtained. The results correlated well with Lovibond values and with comparisons in four different photoelectric colorimeters using filters with a peak transmission peak in the range 435 to 440 mμ with dichromate as a standard. The European industry, with its much greater range in color types, has relied more on empirical standards such as Lovibond slides, see Bishop *(3)*. However, Trolle *et al (17)* found the color composition of worts and beers to be sufficiently uniform so that beers could be adequately characterized as to color intensity by measuring the optical density at 465 mμ and the color type by the ratio of the optical densities taken at 465 and 550 mμ.

Similar trends towards standardization in the food industries in general have been outlined by Mackinney and Chichester *(13)*. They note, moreover, the need of color standards which can be understood on the world market.

EXPERIMENTAL

The wines selected were commercial California types or experimental wines from the Enology cellar. Of these 33 were white and 18 red. Prior to the experiment all were classified into the commercial types chablis (including rhine and Riesling), sauterne, muscatel, rosé, claret (including burgundy and Zinfandel), Cabernet, and tawny port by two experienced wine judges. For this classification the wines were filtered until free of suspended material in an asbestos pad filter and placed in filled one-tenth gallon clear-glass commercial wine bottles.

Four procedures were used for measuring the color: Munsell color plates, a Duboscq color comparator, a Beckman DU spectrophotometer (or in some cases a Beckman Ratio-Recording spectrophotometer) and a Klett-Summerson photoelectric colorimeter. The Munsell color plates were those published in the Munsell Book of Color, Munsell *(14)*. The comparison was made in the same bottles used for the visual comparisons. The color standards employed in the Duboscq colorimeter were those used by Winkler and Amerine *(21)*. In making the transmission curves with the spectrophotometer readings were made every 10 mμ from 380 mμ to 700 mμ. The depth of measurement was 5 to 20 mm. for the whites and 1 mm. for the reds. The calculation of the trichromatic coefficients and subsequently of brightness, dominant wave length and purity were made by the methods of Hardy *(8)*. The photo-electric colorimeter was used with filters 42, 47, 50, 54, and 66 for the whites. The cell was a round 15 mm. test tube. The whites were run undiluted. The reds were undiluted but used with only the 47 filter.

RESULTS

The results have been classified on the basis of the visual classification. Admittedly a classification by only two experts is inadequate. However, only the major types were used and the gross color differences were well marked. Considerable industry collaborative measurements with a wider variety of types and sub-types would be necessary for setting actual standards. However, the wines can be classified on the basis of any of the physical standards or on selected parameters from the transmission curves: optical density at a given wave length, ratio of optical densities at selected wave lengths, brightness, etc.

The results for the lighest colored table wine types, chablis and Riesling, produced in California are given in Table 1. For the wines classified as sauterne or Semillon the results are tabulated in Table 2. With the muscatels, Table 3, the figures were very variable. Both dry and sweet sherreis are included in Table 4, but only wine 24 was classified as a cocktail or pale dry sherry—the lighest colored sherry commercially produced in the state. The data from the transmission curves were obtained at 1 and 5 mm. but have been recalculated to 20 mm. Data on the California rosé type wines are given in Table 5. While the color of the 4 wines selected was considered good, there is a much greater variation among commercial rosés. Zinfandel, claret, and burgundy are not considered to be a uniform group by the industry, but the wines examined were very similar, as indicated in Table 6. Cabernet was classified into a group of full red-colored wines, Table 7. The limited data indicate that

TABLE 1

Color values of chablis and Riesling wines (cell depth 20 mm.)

Wine	Munsell		Duboscq color	Trichromatic coefficient		Brightness	Dominant wave length	Purity
	hue	*value/chroma*		$\bar{x}$	$\bar{y}$	%	mμ	%
1	5 Y	8/8	9.9	.3377	.3549	92	573	18
2	5 Y	8/6	6.7	.3261	.3355	91	575	9
3	5 Y	8/6	6.2	.3252	.3355	94	574	9
4	5 Y	8/6	6.4	.3260	.3365	94	574	10
5	5 Y	8/6	6.3	.3251	.3361	95	574	9
6	5 Y	8/6	8.3	.3298	.3419	94	574	12
7	5 Y	8/8	10.3	.3354	.3500	89	574	16
8	5 Y	8/8	9.6	.3363	.3508	93	574	16
9	5 Y	8/6	5.9	.3291	.3435	95	573	12
10	2.5 Y	8/5	6.5	.3264	.3352	91	575	9

TABLE 2
Color values of sauterne (or Semillon) wines
(cell depth 20 mm.)

Wine	Munsell		Duboscq color	Trichromatic coefficient		Brightness	Dominant wave length	Purity
	hue	*value/chroma*		$\bar{x}$	$\bar{y}$	%	mμ	%
10	5 Y	8/8	13.2	.3431	.3626	91	573	21
11	2.5 Y	7/8	16.2	.3369	.3487	88	575	16
12	5 Y	8/8	14.2	.3411	.3583	92	574	20
13	2.5 Y	7/8	12.0	.3415	.3542	86	575	19
14	2.5 Y	7/10	16.5	.3546	.3703	78	575	26
15	2.5 Y	8/8	13.2	.3472	.3582	86	576	21
16	2.5 Y	7/10	17.9	.3639	.3751	79	576	30
17	5 Y	8/12	17.9	.3523	.3696	87	574	26
18	2.5 Y	7/10	16.9	.3643	.3802	80	575	32

TABLE 3
Color values of muscatel wines

Wine	Munsell		Duboscq color	Cell depth	Trichromatic coefficient		Brightness	Dominant wave length	Purity	Klett[1] reading
	hue	*value/chroma*		mm.	$\bar{x}$	$\bar{y}$	%	mμ	%	
19	5 Y	8/12	25.2	5	.3229	.3315	96(87)[2]	576(576)[2]	8(27)[2]	160
20	10 YR	6/10	25.4	20	.3848	.3994	73	576	42	.....
21	10 YR	7/10	20.3	20	.3702	.3842	76	576	34	.....
22	10 YR	6/10	29.4	5	.3332	.3438	94(79)	575(577)	14(47)	276
23	10 YR	6/10	21.8	5	.3276	.3378	95(81)	574(576)	10(37)	212

[1] 42 filter, 10 mm. cell.
[2] Figures in parentheses refer to calculations made to the standard depth of 20 mm.

TABLE 4
Color values of sherry wines

Wine	Munsell		Duboscq color	Cell depth	Trichromatic coefficient		Brightness	Dominant wave length	Purity	Klett[1] reading
	hue	*value/chroma*		mm.	$\bar{x}$	$\bar{y}$	%	mμ	%	
24	10 YR	7/10	27	5	.3331	.3442	94(79)[2]	575(577)[2]	14(48)[2]	247
25	5 YR	5/10	58	5	.3563	.3650	85(61)	577(579)	27(74)	505
26	5 YR	6/12	71	5	.3482	.3616	86(58)	575(579)	23(68)	450
27	2.5 YR	5/10	103	5	.3870	.3974	74(35)	577(585)	43(92)	1000
28	2.5 YR	4/8	77	5	.3724	.3842	77(40)	576(583)	35(86)	760
29	5 YR	6/12	39	5	.3455	.3612	90(68)	574(578)	22(65)	424
30	2.5 YR	5/10	67	5	.3621	.3760	83(51)	576(581)	30(80)	630
31	2.5 YR	4/8	109	5	.3894	.4064	75(37)	576(584)	45(91)	1000
32	5 YR	5/10	100	1	.3228	.3290	88(11)	577(588)	7(85)	383[3]
33	10 YR	5/8	97	1	.3250	.3273	86(8)	582(592)	7(97)	313[3]

[1] 42 filter, 10 mm. cell.
[2] Calculated to 20 mm. [values in ( )].
[3] Diluted 1 : 2.

TABLE 5
Color values of rosé wines
(cell depth 1 mm.)

Wine	Munsell		Duboscq color	Trichromatic coefficient		Brightness	Dominant wave length	Purity
	hue	*value/chroma*		$\bar{x}$	$\bar{y}$	%	mμ	%
34	7.5 R	5/8	40	.3205	.3192	91	595	4
35	7.5 R	5/10	14	.3176	.3219	93	582	3
36	7.5 R	4/12	51	.3157	.3181	93	595	2
37	2.5 R	4/8	85	.3274	.3087	81	497c	6

TABLE 6
Color values of Zinfandel, claret, or burgundy wines
(cell depth 1 mm.)

Wine	Munsell		Duboscq color	Trichromatic coefficient		Brightness	Dominant wave length	Purity
	hue	*value/chroma*		$\bar{x}$	$\bar{y}$	%	mμ	%
38	7.5 R	2/4	154	.3431	.3395	64	583	15
39	7.5 R	2/4	182	.3599	.3331	63	592	18
40	5.0 R	3/6	122	.3279	.3154	78	630	5
41	7.5 R	3/10	109	.3476	.3243	80	598	12
42	7.5 R	3/4	154	.3576	.3296	64	594	16
43	7.5 R	3/4	192	.3629	.3239	58	602	16
44	7.5 R	3/6	135	.3538	.3287	67	594	15

TABLE 7

Color values of Cabernet wines
(cell depth 1 mm.)

Wine	Munsell		Duboscq color	Trichromatic coefficient		Brightness	Dominant wave length	Purity
	hue	*value/chroma*		$\bar{x}$	$\bar{y}$	%	mμ	%
45	5 R	3/8	192	.3591	.3215	61	605	15
46	5 R	3/6	208	.3574	.3256	58	599	15
47	2.5 R	2/6	280	.3521	.2968	51	497c	16

TABLE 8

Color values of tawny port wines
(cell depth 1 mm.)

Wine	Trichromatic coefficient		Duboscq color	Trichromatic coefficient		Brightness	Dominant wave length	Purity
	hue	*value/chroma*		$\bar{x}$	$\bar{y}$	%	mμ	%
48	2.5 R	4/8	79	.3516	.3512	75	580	20
49	7.5 R	3/10	113	.3483	.3375	72	586	16
50	10 R	3/10	76	.3387	.3390	79	581	14
51	7.5 R	3/10	93	.3466	.3371	73	585	15

TABLE 9

Effects of dilution of wine No. 172–5 with decolorized wine No. 172–5

Per cent No. 172–5	Trichromatic coefficients		Brightness	Dominant wave length	Purity	Duboscq color
	$\bar{x}$	$\bar{y}$	%	mμ	%	
100	.3347	.3478	91.5	574	15	9
93.75	.3326	.3451	92.6	574	14	8
81.25	.3311	.3427	92.5	574	13	7
75	.3295	.3416	94.0	574	12	6.5
70	.3284	.3393	93.6	574	11	6.4
50	.3240	.3352	95.3	573	9	5.6
25	.3186	.3289	97.6	572	6	....
10	.3154	.3249	98.4	571	4	....
0	.3143	.3225	98.7	572	3	....

TABLE 10

Effect of dilution of wine No. 8518 with wine No. 8519
(cell depth 1 mm.)

Per cent No. 8518	Trichromatic coefficients		Brightness	Dominant wave length	Purity	Duboscq color
	$\bar{x}$	$\bar{y}$	%	mμ	%	
100	.3346	.3088	70.8	494c	7.5	89
98	.3336	.3081	70.2	495c	8.0	89
96	.3343	.3078	69.7	495c	8.0	89
95	.3347	.3078	69.6	495c	8.0	93
90	.3346	.3074	68.5	495c	8.5	94
80	.3363	.3050	66.6	497c	9.5	105
75	.3370	.3046	65.9	497c	10.0	108
70	.3380	.3034	64.5	497c	10.5	111
50	.3377	.3006	61.0	498c	11.5	128
30	.3430	.2954	57.6	498c	14.5	149
25	.3426	.2953	57.4	498c	14.5	151
20	.3442	.2938	55.8	499c	15.5	156
10	.3460	.2927	54.6	499c	16.5	167
5	.3464	.2923	54.1	499c	16.5	170
4	.3466	.2917	53.8	499c	17.0	172
2	.3466	.2915	53.6	499c	17.0	172
0	.3473	.2917	53.0	499c	17.0	172

this was justified. The final group tested was tawny port. The aging of tawny port involves a fading of the red and the appearance of more and more amber. Commercial standards are variable, and this is reflected in the color data obtained in Table 8.

To test more adequately the ability of the various procedures in white and red wines the following tests were made. In each case a standard wine was blended with a wine of similar color until the visual differences were very small or indistinguishable. The results with white wines are given in Table 9 and with red wines in Table 10. The visual color differences for 100, 93.75, 81.25, and 75% white wine number 172-5 were very small and several of the laboratory personnel could not detect any visual differences when viewed in 15 mm. diameter test tubes. Blends of 100, 75, 50, 25, and 0% of wine 172-5 when viewed in 15 mm. diameter tubes were detectable visually. Nevertheless, there are small differences in the tristimulus values for all of these wines. It is of interest that slight Duboscq color comparator differences were also observed. For the white wines the data in Table 9 show that the differences in the tristimulus values are sufficient to differentiate between blends of 100, 93.75, 81.25, and 75% of wine number 172-5. The visual color differences for 100, 98, 96, 95, and 90% of red wine No. 8518 were small, in fact, indistinguishable by several laboratory personnel when viewed in 10 mm. test tubes. Admittedly, the test is a difficult one but if the differences can be distinguished in a 10 mm. test

TABLE 11

Tristimulus data with Beckman DU vs. Beckman recording spectrophotometers

	Beckman DU					Beckman recording				
	Trichromatic coefficients		Brightness	Dominant wave length	Purity	Trichromatic coefficients		Brightness	Dominant wave length	Purity
White standard	$\bar{x}$	$\bar{y}$	%	mμ	%	$\bar{x}$	$\bar{y}$	%	mμ	%
25	.3828	.3989	69	576	42	.3790	.3924	71	577	39
26	.3568	.3730	84	575	28	.3563	.3650	85	577	25
	.3530	.3659	85	576	25	.3482	.3616	86	575	23
Red standard	.3391	.2847	63	505c	18	.3500	.2921	61	498c	17
40	.3636	.3280	58	598	17	.3629	.3239	58	602	16
45	.3222		53	605	17	.3591	.3215	61	605	17

tube the visual differentiation in a wine glass presents little problem.

For the red wines the data in Table 10 are encouraging. For a wine of this spectral characteristic blending with a wine of similar spectral characteristic permitted differentiation at only 2, 3, 5, or 10% blends. These tests indicate that very small color differences in red wines permit adequate color differentiation using color characteristics derived from transmission curves.

The question of the duplicability of CIE values from data obtained on two different instruments was also of some interest. The Beckman DU and Ratio-Recording spectrophotometers are compared in Table 11. Using the DU as a standard the characteristics taken from the Ratio-Recording curves seem to be variable. For this reason where small differences are important the Beckman DU should probably be used.

DISCUSSION

The problem of which system to use is a difficult one. Between the CIE system and others it is easy to select the CIE system. However, the average winery does not have the necessary equipment and possibly not the personnel to calculate the color characteristics according to the CIE system. The disadvantages of the other systems are obvious. The Munsell plates *per se* cannot be used directly. Specialized equipment is necessary for accurate measurements. While the results can be converted to the CIE system it is doubtful if any time is saved. Standard color solutions are useful for a single type of wine where *all* the samples have very similar spectral characteristics. But for wines of different color characteristics they are very poor for characterizing the wines. Winkler and Amerine *(21)* needed two standards and these were inadequate for many wines. The same is true of photoelectric colorimeters with or without filters. There are also problems with photoelectric colorimeters using round sample holders due to the variable depth of sample and possible reflection errors.

It is our belief that experience with the CIE system will dissipate some of the prejudice against its use. Naturally, however, the spectrophotometers must be accurately calibrated. The standard observer results for the tristimulus values give good differentiation in the longer wave lengths. In the shorter wave lengths discrepancies occur. Jacobsen *(10)* and Judd *(11)* found that two white oxide pigments, rutile and anatase, which have very similar tristimulus values with illuminant C are easily distinguishable. With very light colored wines the utility of spectrophotometric data in distinguishing the color of wines may be called into question. Le Grand *(12)* suggests that this difficulty results from adoption of values for the relative luminous efficiency factors for the standard observer which are too small in the violet. Furthermore, while the CIE procedures give unique specification of color the actual color perception for different tristimulus values may be the same. Mackinney and Chichester *(13)* show (*their* Fig. 3) that at a dominant wave length of 575 mμ a purity of 0.4 and a brightness of 70% gives a perceived color match with a purity of 2.0 and a brightness of 76. This demonstrates that lightness is just one of the color characteristics which we must learn to recognize in color studies. Similar conclusions are inherent in the data presented herein.

One of the difficult problems of specifying the color of red wines is the possible changes in dominant wave length as the depth is decreased. Wright *(22)* found the dominant wave length of blood to decrease from 620 mμ to 575 mμ as the depth of measurement was decreased. Since wines are served in round glasses the depth of transmitted light is variable depending on the amount of wine in the glass, the size of the glass and the level in the glass at which the color is observed. Although this problem is an aggravating one as far as color characteristics derived from transmission curves are concerned, the ability of such data taken at a constant depth in distinguishing most wine types is not questionable.

The use of abridged color characteristics, such as recommended by Trolle *et al. (17)* and Brandon *(5)* for beer, will be reported in a later paper.

SUMMARY

Standardization of the colors of our standard California wine types is greatly to be desired. Present procedures are inadequate, particularly for distinguishing wines of different spectral characteristics.

The brightness, dominant wave length and purity of 51 California wines of 8 different types has been calculated from their transmission curves. Generally good differentiation of types is possible. The limitations of color standards and of the Munsell system are indicated.

By blending, very small spectral color differences were established for a white and red wine. The tristimulus data were adequate for differentiating red wines of very small color differences. White wines with small color differences were not so easily differentiated from their tristimulus data.

There is a fair but not adequate correlation between the data calculated from transmission curves obtained with a Beckman DU spectrophotometer as compared with a Beckman Ratio-Recording spectrophotometer. The former is to be preferred.

LITERATURE CITED

1. Amerine, M. A. The composition of California wines at exhibitions. *Wines & Vines*, **28** (2), 24; (3), 23, 42 (1947).
2. Amerine, M. A., and Winkler, A. J. Color in California wines. IV. The production of pink wines. *Food Research*, **6**, 1 (1941).
3. Bishop, L. R. Proposed revision of the Lovibond "52 series" of glass slides for the measurement of the colour of worts and beers. *J. Inst. Brewing*, **56**, 373 (1950).
4. Boutaric, A., Ferré, L., and Roy, M. Recherches spectrophotometriques sur la couleur des vins. *Ann. fals. et fraudes*, **30**, 196 (1937).
5. Brandon, A. L. Determination of color in beer, wort and brewing materials. I. Application of trichromatic measurements to the determination of color in beer and wort. *Proc. Amer. Soc. Brew. Chem.*, 1957, 77 (1957).
6. Dujardin, J., and Dujardin, L. & R. Notice sur les instruments de précision appliqués à l'oenologie. 6 édit. Chez les Auteurs, Paris. XII, 1096 p. plates [n.p.] (1928).
7. González Gordon, M. M. Jerez-Xerex-Scheris. Jerez Industrial, Jerez de la Frontera. 1948. 605 p.
8. Hardy, A. C. *Handbook of Colorimetry*. 1936. Technology Press, Cambridge, Massachusetts. 87 p.
9. Instituto Do Vinho Do Porto. A cor no vinho do Pôrto, sua evolucão. Instituto do Vinho do Pôrto. IV p. 15 colored plates (1950).
10. Jacobsen, A. E. Non-adaptability of the ICI system to some near-whites which show absorption in the far-blue region of the spectrum. *J. Opt. Soc. Am.*, **38**, 442 (1948).
11. Judd, D. B. A comparison of direct colorimetry of titanium pigments with their indirect colorimetry based on spectrophotometry and a standard observer. *J. Opt. Soc. Am.*, **39**, 945 (1949).
12. Le Grand, Y. *Light, Colour and Vision*. 1957. John Wiley & Sons Inc., New York. xiii, 512 p.
13. Mackinney, G., and Chichester, C. O. The color problem in foods. *Advances in Food Research*, V, 301 (1954).
14. Munsell, A. H. *Munsell Book of Color*. 1929. Munsell Color Company, Inc., Baltimore. 2 v.
15. Simon, A. L. *Champagne*. 1934. Constable & Co., Ltd., London [3], 140 p.
16. Stone, I., and Miller, M. C. Standardization of methods for the determination of color in beer. *Wallerstein Labs. Commun.*, 12, 335 (1949).
17. Trolle, B., Wyborg, P., and Buchmann-Olsen, B. Trichromatic colour determination in wort and beer. *J. Inst. Brewing*, **57**, 347 (1951).
18. Wallerstein Laboratories. How dark or how light. *Wallerstein Labs. Commun.*, **20**, 1 (1957).
19. Wine Institute. California wine type specifications. Revised May 2, 1956. Wine Institute, San Francisco. 8 p. Mimeographed (1956).
20. Winkler, A. J., and Amerine, M. A. What climate does. *The Wine Review*, **5** (6), 9; (7), 9, 16 (1937).
21. Winkler, A. J., and Amerine, M. A. Color in California wines. I. Methods for measurement of color. *Food Research*, **3**, 429 (1938).
22. Wright, W. D. *The Measurement of Colour*. 1944. London, A. Hilger. 233 p.

An Appraisal of New Processing Methods for Military Foods*

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THE SPECIALIZED FOOD PROBLEMS of the Military leading to the introduction of new processing methods and new food products require for their resolution constant and aggressive research and development in cooperation with American industry and institutional organizations. The Military often has to take the lead in attacking certain problems where the objectives have no immediate civilian interest. The impact of the Military on developments along these lines is clearly presented in the Quartermaster Food and Container Institute publication, "Rations—Yesterday, Today and Tomorrow" *(13)*. The following are examples:

1. Canning was developed by Nicholas Appert to help feed Napoleon's armies. During the Civil War the canning industry in the United States was greatly stimulated. The new process of evaporation of milk and the new product, condensed milk, invented by Gail Borden in 1856, contributed greatly to the nutrition of troops who were subsisting at that time mainly on "dry" rations.

2. World War I gave the soluble coffee industry its initial boost. At the end of that war, 42,500 lbs. were being used daily.

3. During World War I the demand for dehydrated foods to supply our Armed Forces overseas was constantly increased. By 1918, 6,000,000 pounds of dehydrated foods were produced monthly.

4. Canned bread got its start in World War II and was used to a great extent in Korea.

5. In the Korean War, with its food logistic problems, increased respect was developed for dehydrated foods. The need was re-emphasized for extending dehydration to products other than fruits and vegetables, particularly to meats.

6. In Korea fresh fruits and vegetables were added to some menus from hydroponic truck farms located in Japan, with important morale benefits. This stimulated interest in ways and means of extending the storage life and distribution of fresh produce.

The criteria for military foods are: a high order of acceptability, nutritional adequacy, space and weight saving, storage stability, and ease of preparation under conditions of their intended use. Nutritional surveys in recent years have shown that our soldiers have been adequately nourished *(19)*. However, the acceptability of certain ration items, either due to the inherent properties of the product or storage changes, needs to be improved. The problem is mainly one of utility dealing with the last three criteria mentioned, i.e., space and weight saving, storage stability and ease of preparation. In this regard Colonel J. D. Peterman, past Commandant of the Quartermaster Food and Container Institute, has stated as follows *(11)*:

"It will come as no surprise to any of you, I am sure, that the term 'atomic warfare' has come into common use. Logistic and strategic methods have been undergoing drastic revision. Increased attention is being given to the coordination of all elements of defense in order to attain the ultimate in the simplification of supply systems, greater economy in the use of our combat forces plus increased speed and maneuverability. The nuclear bomb has given us—and the unfriendly powers—massive striking power. All of this means that there has come upon us the paramount requirement that supplies must not be conspicuous and that our forces must be held in comparatively small, dispersed groups capable of quick tactical shifts away from one area and into another.

"Against this rigid set of requirements we can immediately see one important impact on rations. Well-equipped, stabilized food storages, kitchens, and messing facilities can no longer be considered feasible—neither within the zone of combat nor in the immediate supporting area. Such a setup would furnish too attractive a target. Existing rations will probably continue to serve special purposes but research and development has now turned to new feeding concepts and new rations—such as the so-called dehydrated, precooked complete meal."

The needs of the Navy must be recognized for the maximum utilization of galley space for food preparation and storage. Dehydrated foods which occupy only ⅛ the storage space, as compared with non-dehydrated, seem to be the answer. On the larger Navy vessels freezer and refrigerator space of considerable size is available. This allows diversification of the menu to include frozen milk, meat and vegetables. On our atomic-powered submarines food, not fuel, is the item determining distance of travel.

The Air Force has its specific problems of feeding combat and transport crews and fighter pilots. The problems here vary from those involved in the use of warmed, precooked frozen meals and flight lunches to the tube pressure feeding of fighter pilots.

A review of "Current Operational Rations Used by the Armed Forces" *(3)* and "What the Armed Forces Require in Foods and Containers" *(18)* has provided additional background for this discussion of the merits of new processing methods for military ration items. The term "new processing methods" is defined as a procedure, new or old, which produces a product which, compared to existing ration items,

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, May 26, 1958.

better meets military characteristics. The processes which will be discussed are canning, refrigeration, antibiotics, dehydration, dehydro-canning, and irradiation treatment.

CANNING

Canning has for years been the "standby" for military feeding, and no doubt still will be in the future, particularly for feeding large groups of men. Although high-temperature, short-time (HTST) processing offers product improvement in many instances, it does not offer help to some of the ration items where improvement is needed. Canned meats cannot be materially improved by HTST. Formulation seems to offer the greatest potential for overcoming this problem. However, canned soups, whole kernel and cream style corn, and whole milk may be improved in quality and acceptability by HTST processes. These items are of military interest. By HTST methods whole kernel corn and cream style corn can be given sufficient heat treatment to destroy thermophilic bacteria without downgrading product quality. Excellent whole milk can be canned but its storage life is limited, dependent upon the temperature of storage. If some cool storage is provided, acceptability can be retained for at least 3 to 6 months.[b] University of Wisconsin researchers have recently announced a sterile milk concentrate which may have possibilities. One must realize, however, that there is competition between processes for many ration items. Dried milks of high acceptability are now available. These have the advantages of space and weight saving and storage stability.

The Air Force is presently using individual sized cans of solid food which can be opened at take-off or in-flight and eaten during the mission. For high altitude feeding, the American Can Company has developed a technique for filling, sealing, and sterilizing various meat pastes in metal tubes. These products are presently under trial by the Air Force.

REFRIGERATION

During World War II the development and use of frozen boneless beef (3-way and 4-way) was a significant contribution *(7)*. Space and weight saving for fresh meat was reduced to a minimum. Headquarters, United States Air Force, in the last few years has granted the storage of frozen meat where facilities permit. The Air Force has at least 12 menus of precooked frozen meals for flight training *(3)*.

The Research and Development Division, Office of the Quartermaster General, has published data on "Optimum Conditions for Storage and Handling of Semi-Perishable Subsistence Items." This publication supports the view that refrigerated storage would maintain the quality of dry and processed foods and would prolong stability to at least five years.

There is no doubt that refrigeration will be used for military rations in peace and war to the extent of the facilities. There has been a great expansion in refrigeration warehousing space in the last 10 years. Refrigerator storage (32–50° F.) of processed foods to prevent storage degradation is a definite possibility. A report of studies made by the Quartermaster General's Office indicates that the use of refrigeration for ration items is economical. "It eliminates rapid turnover of expensive food and curtails the use of food for purposes not originally intended. If and when a program of storage of operational rations under refrigeration is implemented in overseas theatres, less acceptable foods will be served less frequently and our problem of curtailed nutritional intake will be simplified" *(5)*.

Combination processes such as antibiotics and refrigeration and radiation and refrigeration offer definite possibilities for military use. Of particular interest should be the insurance value of such processes for food stability in cases of refrigeration equipment failure. This is a concern of the Navy on ships during combat duty.

[b] The Military demands stability and acceptability for six months at 100° F.

Refrigeration cannot be utilized with the fast-moving mobile Army envisaged for the future. Logistics are simplified in ultimate degree. It is for this reason that active research efforts are applied to dehydration and irradiation to eliminate the need for refrigeration. Wodicka has stated that dehydration, radiation, and canning—separately or together—should give us for the first time a non-perishable ration which will eliminate the need for refrigeration *(19)*.

ANTIBIOTICS

As a result of the extensive work of Deatherage *(4)* and his associates, it has been shown that aureomycin, terramycin, and chloromycetin effectively retard spoilage in meat. Beef animals infused with aureomycin *post mortem* via one carotid artery produced meat of considerably lower bacterial count and longer storage life. The bacterial content of untreated meat increased rapidly if the carcass was not chilled soon after slaughter. Surface growth of bacteria on carcasses was greatly inhibited by aureomycin spray.

It would seem practical to use chlortetracycline- and oxytetracycline-treated beef for frozen boneless 4-way beef. A lower original bacterial count would be attained which, with the small amounts of antibiotic present, would provide resistance to spoilage in case of refrigerator equipment failure. Of greater importance, the product could endure more temperature abuse in shipping and perhaps reach destinations of consumption the untreated could not reach.

For irradiation treatment a lower bacterial count in the original product may enable a lower radiation dose and less off-flavor development.

Use of antibiotic poultry dips for poultry for military use has its advantages for both raw and frozen poultry and undoubtedly is in use today. The treatment of vegetables *(2)* and fish *(14)* with antibiotics for the purpose of extending refrigerator storage life has some military interest.

DEHYDRATION

Dehydration, of course, is not a new method of preservation. It has been used in all of our recent wars. If we should get into a war within the next 5 years, it would be necessary to depend upon it again. The dehydration industry feels that in case of an emergency, it can again take care of the needs of the Armed Forces. Since the logistics of supplies for the fast-moving mobile Army of modern times are different from those of the past, the need for dehydrated foods for the military is perhaps greater now than heretofore.

Since World War II great progress has been made in dehydration. Not only have dehydration procedures been perfected, but the importance of reducing the moisture content of dehydrated products to a very low level to produce stable products has been demonstrated *(16)*. "In-package desiccation" has brought about a reduction of the moisture content of the product to 1% or less, providing greater stability of the original characteristics of the product than previously could be attained.

The four principal methods of dehydrating are (a) spray drying for liquids and semi-liquids, (b) hot air drying for vegetables, (c) vacuum drying for juices and, finally, the new freeze drying process. Tressler *(16)*, Tischer and Brockman *(15)*, Goresline *(6)*, and Blair *(1)* have discussed the improvement in the technology of these dehydration methods which have brought about new and better dehydrated foods for the Military. Specifically, aside from "in-package desiccation," which produced a greater stability in dehydrated foods, these developments are:

1. Precooked dehydrated foods which can be reconstituted with cold or boiling water. The following items were listed in the Feb. 1957 Master Menu:[c] apples, eggs (whole, dried), milk (whole, dried), potatoes (white, diced or granules), soups chicken noodle or pea), and dehydrated onions. The following

[c] The universal menu prescribed for U. S. Army feeding within the continental U. S. A. and, as applicable, overseas.

additional products have been made available by work at the Quartermaster Food and Container Institute: beefsteak, pork chops, beans (green snap), soups (lima bean, cream of onion, cream of potato), grapefruit juice, orange juice, and sweet potatoes. The 25-in-1 and 5-in-1 "quick-serve meals" are under development and include such items as frankfurters and beans, chicken and rice, and chili with beans.

2. Freeze-dried meat, an important development with great potentials for the Military. When dehydrated to 2% moisture or less, a stable product is obtained. Rehydration is rapid and quality is excellent. Unfortunately, it takes 20-24 hours to dehydrate a steak. Consequently, production is slow and costly. The cost of freeze-drying beefsteaks is approximately 45¢ per lb. of dried product, or 15¢ per lb. of original or rehydrated product. Attempts have been made to justify this original high production cost by the lower shipping cost. Comparing the freeze-dried against canned meat for 2000 miles shipment by rail, 2400 by boat, and 1000 miles by plane, the break-even point for the cost of processing and shipping combined is about 200 miles from the final destination or supply depot.

3. Dehydrated tomato juice and orange juice. These are relatively new products. Both may be prepared satisfactorily by the "puff" vacuum technique or, for the highest quality, by vacuum dehydration. Both orange and grapefruit "crystals" are being commercially produced by this process today.

4. Dehydrated peas, corn, lima beans, and green beans. These products are now very successfully dehydrated and have excellent retention of quality factors.

DEHYDROCANNING

This process involves the evaporation of about half the water and subsequent processing in the can *(8)*. It has been particularly successful on sliced apples. This product is being produced commercially in No. 10 cans and has received favorable reception by pie bakers and institutional users. Because of the space and weight saving, this product is of interest to the Military. Pears have also been successfully canned by this process, but for many other fruits the process has not been particularly encouraging.

RADIATION

Considerable discouragement has prevailed over the future of radiation sterilized foods since it was reported that a minimum dosage of 4,800,000 rep was calculated for the destruction of *Cl. botulinum (9)*. Yet, we find pork loin sterilized with this dosage coming through with a favorable acceptability in recent Fort Lee tests. Morgan and Pomerantz *(10)* have reported on pork loins which were irradiated and stored for 9 months at 70° F. Color, acceptability, and nutritive value were retained over this period. Sliced bacon (low salt) has been irradiated and stored at both room temperature and cool storage with excellent results. These products, like all others tested, have been proved to be safe toxicologically. The fact that milk can be sterilized with an acceptable flavor by removal of the volatiles during the irradiation process *(12)* has been most encouraging. The important research and development work conducted under the Quartermaster Food and Container Institute Radiation Program has shown that pork loin, bacon, chicken meat, smoked fish, crab meat, and sweet potatoes can be preserved by radiation in cans and stored for several months without substantial change in flavor *(17)*.

Costs of radiation sterilization of foods have been projected in the range of 2 to 5 cents a pound. Mechanical generators of food plant capacities are becoming more realistic every day. Since costs are projected on a dosage basis, pasteurization treatments should be much cheaper than sterilization.

Pasteurization with low dosages may be used to extend the cool storage life and temperature abuse of fresh meats and poultry. The storage life of citrus products and strawberries has been extended by a factor of 4 by radiation surface treatments. Of particular importance in this regard is the treatment of pre-wrapped sandwiches. When sealed in flexible wrappings and "pasteurized" by low-dosage radiation, sandwiches may be kept fairly fresh for several weeks. Presently, the Air Force prepares sandwiches not longer than 5 hours before they are eaten in flight. Even then there is always the danger of staphylococcus food poisoning.

Other uses for radiation of foods for military purposes are most promising. These are:

1. Prevention of insect infestation in flour. When stored for 9 months at 70° F., satisfactory baking properties were retained.
2. Extension of shelf life of baked goods.
3. Inhibition of sprouting of potatoes.

Favorable results have been obtained, in several instances, with low-dosage treatments of fruits and vegetables other than those mentioned. Since these products in most instances can be most favorably preserved by other processing methods such as canning and dehydration, they are omitted from this portion of the discussion.

Tressler *(17)* has stated "from a military standpoint it is probable that many foods may be radiation sterilized for use in feeding the troops behind the lines; others may be 'pasteurized' in order to give a greater variety of rations to men in the front lines."

CONCLUSION

Each of the methods of processing food which has been discussed is in competition with one or more other methods. In this regard, the statement by Colonel J. D. Peterman *(11)* regarding radiation treatment of foods seems most appropriate:

"I would like to . . . exemplify another difference between military and commercial objectives in food research and development. The Armed Forces are relying on foods preserved by radiation to offer, among other advantages, an alternate food resource in the event of atomic warfare. You are all familiar with the fact that one of the principles of Armed Forces procurement is to have a diversity of supply resources. That is one of the reasons why industrial mobilization exists. Radiation-processed foods should reduce the burden on other modes of food preservation and increase as well the variety of foods available for use in combat zones. We are also anticipating that radiation-treated foods will fulfill that desire for freshness of taste and texture. In Korea we partially achieved this goal the hard way—by producing fresh produce by hydroponic farms in Japan and flying it in."

LITERATURE CITED

1. Blair, J. M. Development of dehydrated foods—some technological complexities. *Activities Report* (Research and Development Associates, Food and Container Institute, Inc., 1819 West Pershing Road, Chicago), 9, 280 (1958).
2. Carroll, V. J., Benedict, R. A., and Wrenshall, C. L. Delaying vegetable spoilage with antibiotics. *Food Technol.*, 11, 490 (1957).
3. Current Operational Rations. April, 1956. Research and Development Associates, Food and Container Institute, Inc., 1819 West Pershing Road, Chicago.
4. Deatherage, F. E. The use of antibiotics in the preservation of foods other than fish. Publication 397, National Academy of Sciences, National Research Council, Washington 25, D. C., p. 213 (1956).
5. Finkelstein, B. Nutritional aspects of Air Force feeding. Available from Food Service Branch, Air Force Services Division, Wright-Patterson Field, Dayton, Ohio.

6. GORESLINE, H. E. Dehydrated foods—present status. *Activities Report* (Research and Development Associates, Food and Container Institute, Inc., 1819 West Pershing Road, Chicago), 9, 275 (1958).
7. GRAF, R. L. Technologist explains how and why the Army QM developed new 4-way boneless beef plan. *Meat*, p. 26 (December, 1949).
8. KAUFMAN, V. F. Costs and methods for pie-stock apples. *Food Eng.*, 23, 97–105 (1951).
9. MORGAN, B. H. Current status of radiation preservation of foods. *Food Processing* (June, 1957).
10. MORGAN, B. H., AND POMERANTZ, R. H. Radio-sterilization of foods. *General Electric Radiation Digest*, Third quarter (1956).
11. Personal communication: Prof. B. E. Proctor, Mass. Inst. of Technol.
12. PETERMAN, J. D. Motivations for Department of Defense research on rations. *Food Technol.*, 10, 512 (1956).
13. Rations—yesterday, today and tomorrow. June, 1956. Quartermaster Food and Container Institute for the Armed Forces, 1819 West Pershing Road, Chicago.
14. STERN, J. A., LIEBMAN, H. L., KUDO, G., CHAPEL, J., OLSEN, R. A., FARBER, L. L., AND GRENNAN, M. The potential application of antibiotics in the salmon canning industry. *Food Technol.*, 12, 132 (1958).
15. TISCHER, R. G., AND BROCKMAN, M. C. Freeze-drying ups quality of QM quick-serve rations. *Food Eng.*, 30, 110 (1958).
16. TRESSLER, D. K. New developments in the dehydration of fruits and vegetables. *Food Technol.*, 10, 119 (1956).
17. TRESSLER, D. K. Retrospect 1950–1958. *Activities Report* (Research and Development Associates, Food and Container Institute, Inc., 1819 West Pershing Road, Chicago) 10, 31 (1958).
18. What the armed forces require in foods and containers. Series from *Food Industries*, 22 (March through December, 1950).
19. WODICKA, V. O. Food logistics. *Quartermaster Review* (November-December, 1957).

Use of Chlorine Dioxide for Cannery Sanitation and Water Conservation*

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CONSERVATION of potable water supplies is an increasingly important consideration in industries utilizing large volumes of water in their processing operations. Food processors must use some scheduled sanitizing treatment if they are to operate in a manner consistent with the public interests which they serve.

Chlorination of in-plant water supplies *(2, 3, 4, 5, 7)* is widely practiced in the canning industry, but has not been completely successful in controlling bacterial build-ups in reused cannery water. High organic material levels often prevent successful rechlorination, since chlorine reacts quickly with organic matter. Chlorine dioxide, which does not react rapidly with organic matter, appeared a potential answer.

Chlorine gas *(4, 6)* and chlorine dioxide *(7)* have been reported as useful in maintaining potable water. In the use of chlorine gas, the bactericidal action is caused by the hypochlorous acid formed when the gas reacts with water. Reports *(6)* indicate that this type of chlorination of recirculated water is not entirely satisfactory as the high level of organic material in the water makes breakpoint chlorination impractical. The use of chlorine dioxide has been successful for flavor and odor control of drinking water *(7)*. This compound is an efficient germicide in the presence of organic mattter; with its use, breakpoint chlorination is not a necessity.

The substitution of chlorine dioxide for chlorine in treating the water supply of a cannery in Maine eliminated off-flavors due to chlorophenols caused by the interaction of chlorine with phenolic material present in the water supply *(1)*.

As an outgrowth of this and other field work, the study reported in this paper was initiated to investigate the bacterial and sporicidal ability of chlorine dioxide and chlorine solutions both in the laboratory and in a canning plant during two packing seasons with both peas and corn.

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 27, 1958.

EXPERIMENTAL PROCEDURE

The studies were conducted at the Green Giant Company's Blue Earth, Minnesota plant, during the 1956–57 seasons. In brief, the work consisted of taking water and product samples at suitable intervals from various key unit operations, testing for chlorine, and determining total bacterial counts. Results of these tests, taken over a period of several days, were then analyzed statistically. The schematic diagram in Figures 1 and 2 best explains the use of water in this study. Detailed procedures covering sampling and data analyses will be found under Sampling Procedure.

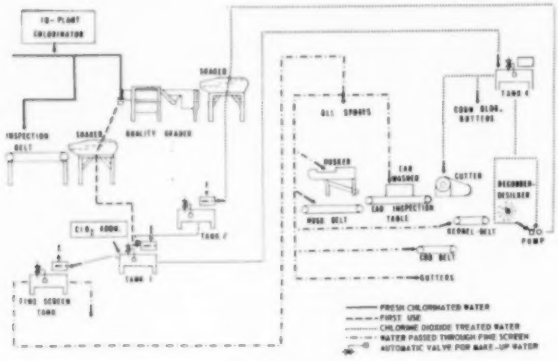


Figure 1

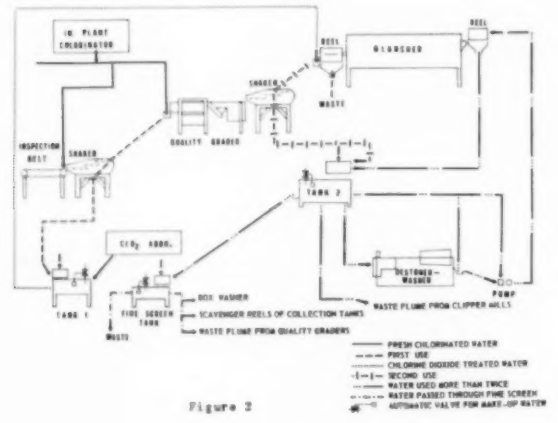


Figure 2

SAMPLING PROCEDURE

Pea and Corn Operations

Phase 1. Three days of sampling with no treatment other than normal in-plant chlorination.

Phase 2. Three days of sampling with in-plant chlorination of fresh water, plus chlorine dioxide treatment of once-used water.

The experimental design for the 1957 corn pack was identical with that of the 1956 study except that some sampling stations were changed to explore aspects of chlorine dioxide use not studied in 1956. In addition the effect of chlorine dioxide on thermophilic flat-sour spores was investigated.

Samples for bacteriological analysis were taken from each unit operation at 2–5 minute intervals, and simultaneously checked for free chlorine residuals by means of a Wallace and Tiernan ortho-tolidine (O.T.) color comparator. In the 1956 studies the chlorine dioxide concentrations were determined by multiplying the O.T. test by five since only ⅕ the total available chlorine present as chlorine dioxide shows as free chlorine.

In 1957, a modified ortho-tolidine arsenite test was used to measure total residual chlorine, available chlorine as chlorine dioxide, free chlorine residual, and combined chlorine to eliminate interfering substances *(7, 8)*.

For studies of the sporicidal properties of chlorine dioxide, the concentration of chlorine and chlorine dioxide were determined by the O.T. color comparator. It was found that with chlorine dioxide in demand free water, the O.T. flash test was only ⅕ of the iodometric test. Therefore, the O.T. test was used for determining the concentrations and this reading was multiplied by five to give actual concentrations.

All bacteriological samples were collected in sterile test tubes containing 0.5 ml. of a 0.1N sodium thiosulfate solution, and total plate counts made on a tryptone glucose extract agar (Difco). Plates were incubated at 30° C. for 24 hours prior to counting.

CHLORINE DIOXIDE GENERATOR

The chlorine dioxide generator installed in the Blue Earth plant (1956) was used to treat recirculated water for fluming cut corn to various unit operations. The generator consisted of a proportionating pump, mixing chamber, and a 50-gallon stone crock for the sodium chlorite solution. Briefly, the unit supplied chlorine gas and sodium chlorite at a 1:1 ratio to a reaction tower, where at a pH range of 3.0 to 3.5, chlorine dioxide and sodium chloride were formed. This chlorine dioxide solution was fed into the recirculated water system after the water had been used to flume the peas or corn from the gravity separator to the final inspection belt.

The sodium chlorite solution may be prepared in any concentration varying from 1 lb. in 8 gallons of water to 2 lbs. per gallon.

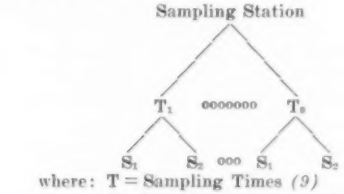
With a 1:1 ratio of chlorine gas to sodium chlorite, the following chemical reaction may be assumed:

$$2\ NaClO_2 + Cl_2 \longrightarrow 2\ ClO_2 + 2\ NaCl$$

Chlorine dioxide solution has a characteristic yellow-green color. This color will vary with the quantity and concentration of the chlorite solution. If the green color is not present, chlorine dioxide is not being generated and the equipment should be checked.

DATA ANALYSIS

In this study, the following experimental design was used at each sampling point:



where: T = Sampling Times *(9)*
S = Samples drawn at each time *(2)*

The resulting data were analyzed by standard statistical methods appropriate to this experimental design.

RESULTS

Chlorine dioxide and chlorine solutions as sporicidal agents. One of the major bacteriological hazards of processors of low acid vegetable products arises from thermophilic spore formers. The thermophilic flat-sour organism is particularly insidious and since no satisfactory bactericidal agent for control has been developed, the thermal process and well regulated can storage temperatures must be relied upon at this time for control. The effect of chlorine and chlorine dioxide on T.F.S. No. 1518–42 suspension from the Continental Can Company culture collection was examined in M/120 phosphate at pH 7.20.

Spore reduction by chlorine and chlorine dioxide solutions could be demonstrated only by exposing spores to a mild heat treatment (15 min. @ 212° F.) prior to contact. Presence or absence of organic matter (W. K. Corn infusion, pH 7.20 in M/120 phosphate) bactericidal solution concentration, and exposure time showed no great differences between chlorine and chlorine dioxide. Major count reduction took place during the first minute of exposure.

In this work it was found that the demand of corn-infusion water to maintain a free residual using chlorine was twice that for chlorine dioxide. With chlorine, slightly obnoxious odors developed up to 5 p.p.m., worsened to 14 p.p.m. and then lessened. Odors from chlorine dioxide solutions were not objectionable to 20 p.p.m.

Owing to the low level of flat-sour contamination in the factory's operations, no evaluation of the available data was practical.

W. K. CORN—1956

As shown in Table 1, without chlorine dioxide treatment, total bacteria counts on product and in the water increased drastically.

TABLE 1

1956 corn study. Total bacterial count per milliliter

Sampling point	In-plant chlorination only	Variable No. 1[1]	Variable No. 2[2]	Variable No. 3[3]
1. Kernels from final inspection belts	61,100	767,611	146,022	144,444
2. Water from Reclaiming Tank 1 (water after first use)	406,000	543,370	606,666	196,811
3. Dewatered kernels before kernel washers	376,444	1,052,444	1,134,000	263,333
4. Water from Reclaiming Tank 2	234,777	238,022	269,000	71,997
5. Water before ear washers (water prior to last use)	15[4]	238,833	452	33,775
6. Water after use in ear washers (water after last use)	186,544	1,868,833	130,517	233,156

[1] *Variable No. 1.* Same as In-Plant Chlorination except water from Fine Screen Tank used in sprays at ear washers, huskers, cob belt and flume and husk and kernel conveyor belts.

[2] *Variable No. 2.* Same as Variable No. 1 with chlorine dioxide added to Fine Screen Tank.

[3] *Variable No. 3.* Same as Variable No. 1 with chlorine dioxide added to Tank No. 1.

[4] Fresh Water.

Adding chlorine dioxide to the fine screen tank to give a residual of 10 p.p.m. greatly reduced the bacterial population in this water as indicated in Table 1 under variable No. 2 for *water before ear washer.* Product counts dropped correspondingly although not to the level found when only fresh chlorinated water was used in the sprays.

The very low counts found in the chlorine dioxide-treated water suggested a final variable in which chlorine dioxide was applied to Tank 1 water. A residual of 0.7–1.0 p.p.m. in this water improved the bacterial condition of water in Tanks 1 and 2, although condition of the final product remained the same.

With regard to residuals, a 10 p.p.m. residual of chlorine dioxide dropped only to 2.5 p.p.m. in passing through the ear washers, indicating an unexpected residual tenacity. On addition of chlorine dioxide to tank 1, this was further evidenced by a 0.5 p.p.m. residual in water after the ear washers when a 0.7 p.p.m. residual was achieved in Tank 1.

At the outset of the 1957 work, arrangements were made to introduce chlorine dioxide into the flotation washers which are actually pea gravity separators. These separators operate during corn pack with a closed recirculation of water to which fresh make-up water is constantly added. It was hoped that this water could be bacteriologically improved by the addition of chlorine dioxide. This did not prove to be the case. Heavy intolerable chlorinous odors built up when sufficient chlorine dioxide was added to give a trace residual. The odor might have resulted from the build up of chlorine in the water in excess of that used in generating chlorine dioxide, although this is not known to be so. Consequently, this part of the experiment was abandoned.

Bacteriological results of the 1957 corn study are listed in Table 2.

TABLE 2

1957 corn study. Total bacterial count per milliliter

	In-plant chlorination only	In-plant chlorination plus chlorine dioxide treatment of reclaimed water
1. Kernels from final inspection belt	489,500	54,640
2. Water from Reclaiming Tank 1 (water after first use)	803,500	11,350
3. Dewatered kernels after the kernel washers	480,000	37,140
4. Water after pumping kernels to kernel washers	916,000	30,130
5. Water from Reclaiming Tank 2	1,097,000	25,460
6. Water from Fine Screen Tank	1,183,000	45,170
7. Water after use in ear washer	1,948,000	39,380

Use of chlorine dioxide drastically reduced counts. It was found that a chlorine dioxide residual of 2.0 p.p.m. in Tank 1 generally gave a trace residual in water after the ear washers just before disposal. Tank 1 water, where chlorine dioxide was added, had the lowest counts with a gradual increase in counts up to the fine screen tank. No explanation of increase in kernel bacteria count from the washers to the final inspection could be found.

Results of the 1957 pea study are given in Table 3.

As in the 1957 corn study, a great reduction in bacteria counts resulted from use of chlorine dioxide. It is of interest that counts on peas did not rise as a result of passing through the gravity separators; also, the heavy contamination on incoming peas is removed in the blanchers and by fresh water sprays in the blancher discharge reels.

Total counts on peas in this study after the blancher without use of chlorine dioxide should not be considered high. In this regard, trace residuals of chlorine could be detected after one use with a 0.25 p.p.m. initial residual. When once-used water was treated with chlorine dioxide to a 3.5–4.0 p.p.m. residual, the destoner flume water gave up to a 2.5 p.p.m. residual and at least a trace residual just before ultimate disposal.

Again, the low levels of thermophilic flat-sour contamination prevented study of the effect of chlorine dioxide on the spores.

TABLE 3

1957 pea study. Total bacteria count per milliliter

	In-plant chlorination only	In-plant chlorination plus chlorine dioxide treatment of reclaimed water
1. Peas at the dewatering screen before the gravity separators	25,880	898
2. Peas from the wash reels after the gravity separators	27,670	608
3. Water from Reclaiming Tank 1 (water after first use)	28,300	370
4. Water from Reclaiming Tank 2 (water after second use)	34,675	1,097
5. Water from Fine Screen Tank (water prior to last use)	71,210	1,826
6. Peas from flume between destoner-washers and dewatering reels before the blanchers	359,200	416,050
7. Peas after the wash reels after the blanchers	32,599	327

DISCUSSION

Whole kernel corn. The water treated by chlorine dioxide had a much lower average total bacterial count than the in-plant chlorinated water when water samples were drawn after

the earwasher and after the gravity separator. The water treated by chlorine dioxide in all reclaiming tanks had a significantly lower average total bacterial count than the in-plant chlorinated water. It is, therefore, concluded that the effect of treating the water with chlorine dioxide was apparent even after this water was reused.

After the gravity separator the kernels which had been in contact with chlorine dioxide-treated water had a lower average total bacterial count than the kernels in contact with in-plant chlorinated water. This effect was still apparent when the kernels were sampled at the end of the inspection belt.

Peas. The initial average total bacterial counts of the peas used in the chlorine treatments were not significantly different even though the two water treatments were used in the plant approximately a week apart. This fact indicated that the bacterial contamination of the two lots of product separated in time was uniform and that any significant decrease in bacterial count after the product was in contact with the water treated by the two different methods was due to the bactericidal action of the treatments, not to initial differences in total bacterial counts.

After blanching, the products in contact with chlorine dioxide-treated flume water showed a substantially lower average total bacterial count than the product flumed to the blancher by in-plant chlorinated water. This effect was still very highly significant after the gravity separator. Furthermore, there was no significant decrease in average total bacterial counts after the blancher and after the separator, even though the peas were flumed to the separator by water treated by the two methods. This fact indicated that the greatest bactericidal effect of chlorine dioxide occurred at the blancher and that no further reduction in the average total bacterial count resulted from the use of chlorine dioxide treated water when the product was flumed to the gravity separator.

Reclaimed tank water treated by chlorine dioxide had a much lower average total bacterial count than when in-plant chlorinated water was used. This was true for all three reclaiming tanks.

Flavor. The delicate flavor of some canned vegetables, such as peas, is frequently detrimentally altered by water treatment additives. For this reason, peas were canned in solutions containing 5, 10, 50 and 100 p.p.m. of chlorine dioxide. Although high concentrations of chlorine dioxide (50 and 100 p.p.m.) caused disagreeable off-flavors, no detrimental effect was noticed at levels of normal use, and it should be noted, peas are packed in brine containing no chlorine dioxide.

WATER CONSERVATION

The prime object of the study was water conservation. The volume of water saved varied. During the corn pack, reused water was substituted for fresh water in 13 ear washers, each of which requires 10 gallons per minute. In addition reused water replaced fresh water at the huskers, cob belt sprays, flume, and also for the husk and kernel conveyor belt sprays.

The pea box washer, in which 80 gallons per minute reclaimed water was substituted for fresh water exemplifies pea pack operations. In addition, used water replaced fresh water in the scavenger reels of Tanks 1 and 2, and in waste flumes from the gravity separators.

SANITATION

Only minor deposits of slime were detected on equipment and belts containing or being sprayed with water containing chlorine dioxide even after many hours of factory operation. The slime detected was granular and easily removed. The granular film was similar in nature to that observed on equipment adequately treated with chlorinated water in other studies. When in-plant chlorination alone was used, however, slime was detected within 12 hours after a major clean-up.

Much of the effectiveness of chlorine dioxide can be attributed to its bactericidal residuals in the presence of organic matter. In addition, no obnoxious odors are generated.

CONCLUSIONS

Chlorine dioxide treatment of once-used water is highly effective in controlling bacteria and slime formation in pea and corn canneries. The persistent residuals and the lack of reaction with ammonia nitrogen make possible one-point rather than multiple-point application as required in rechlorination of used water. Bactericidal residuals maintained in used water do not result in generation of offensive odors in the factory nor do they appear to result in off-flavor in the product. Total bacteria counts on product were significantly lower when chlorine dioxide was used.

Chlorine dioxide cannot be considered more effective than chlorine in controlling thermophilic flat-sour spores. Chlorine dioxide residuals are more easily maintained in the presence of organic matter without generation of nitrogen trichloride; therefore, indirectly, chlorine dioxide may be considered a more effective sporicide.

Substantial savings in water may be realized through reuse of water treated with chlorine dioxide to control bacteria.

Acknowledgment

The authors are grateful to the Wallace & Tiernan Company for supplying the manual gas chlorinator, chlorine dioxide generation tower, and sodium chlorite solution pump, also Mae-Goodwin Tarver of the Statistical Section of the Metal R & D Department of Continental Can Company for the experimental design and statistical analysis of the data.

LITERATURE CITED

1. Continental Can Company. (Unpublished data, 1949.)
2. Griffin, A. E. Break-Point Chlorination Practices. Wallace and Tiernan Company, Inc. *Technical Publication No. 213.*
3. Hall, J. E., and Blundell, C. C. The use of break-point chlorination and sterilized water in canning and freezing plants. National Canners Association *Information Letter No. 1073,* February 12, 1946.
4. Harris, J. J. Chlorination in the food plant. *Canner,* 103 (9) 18–20 (1946).
5. Mercer, Walter A., and Somers, Ira I. Chlorination in food plant sanitation. *Advances in Food Research.* New York: Academic Press, Inc., Publishers. 1957.
6. Mercer, W. A., and Townsend, C. T. Water reuse in canneries. National Canners Association (1954).
7. Olin Mathieson Chemical Corporation. Treatment of water supplies with chlorine dioxide (1956).
8. *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes.* 10 Ed., 1955.

Relation of Chemical Composition and Some Physical Properties to Potato Texture[a]

(Manuscript received July 19, 1958)

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PROCESSING QUALITY in potatoes is judged largely by the texture of the cooked tuber. It is generally agreed that boiled, mashed, and baked potatoes should have a moderately dry to dry mealy texture *(8)*.

Several measurable factors have been shown to be related to texture, but specific gravity has most often been found to be correlated with potato texture *(2, 4, 9)*. Although the use of this factor has been suggested as a practical method for quality separation of potatoes, it has been demonstrated that quality as measured in this manner was influenced by fertilizers, maturity, cultural methods, variety, locality, soil, seasonal variations, and by handling and storage conditions *(3, 7, 10)*. Consequently, there still exists a need for information concerning the relation of variations in potato texture to chemical composition and physical properties. In a recent study it was indicated that maximum relative viscosity of suspensions of lyophilized tissue when gelatinized in a Brabender Amylograph was associated with mealiness *(11)*. The present study was undertaken to determine whether or not certain physical properties and chemical compositional factors were related to variations in texture.

EXPERIMENTAL

The potatoes utilized for this study were produced during the 1956 season. The varieties, Russet Burbank, Sebago, and Katahdin were grown on organic (muck) soil; the varieties Kennebec, Red Pontiac, and Early Gem were grown on sandy loam soil. Tubers were held in storage at approximately 50° F. until evaluated. Data collected should be typical for potatoes produced in Indiana. Other than irrigation on the sandy loam soil, the potatoes were grown under standard cultural practices and harvested at maturity. Potatoes of U. S. No. 1 grade were used in all cases. The specific gravity was determined for four 3.63 kilogram lots from each variety with a potato hydrometer.

Organoleptic tests. Texture qualities of potatoes were determined by a trained panel. Panel members represented both a wide range of ages and a variety of areas of the United States. To assure uniform sampling, one cylindrical plug of one centimeter in diameter was cut from the central region of each of 20 randomly selected tubers from a variety. The potato plugs were boiled for 10 minutes in distilled water. The ratio of water to potato was two to one. Samples were served warm without the addition of salt or other seasoning. Samples were served according to the Plan 11.4, a balanced incomplete block design, described by Cochran and Cox *(5)*. Three samples were served at each session. Panel members were trained to score the samples for texture in an ordinal arrangement of one to three; they assigned a score of 1 to the soggiest sample and a score of 3 to the mealiest sample. Each variety was scored by the panel 5 times, giving a total of 50 judgments per variety.

Measurement of moisture by conductivity. Ten potato plugs from each variety prepared in the same manner as those used in the panel analyses except cut to uniform 4-centimeter lengths were used in this study. Polished copper plate electrodes were fitted on the two ends of the cooked potato plug and connected to the RX circuit of a Bouyoucos Bridge. Constant and equal pressure across the electrodes was applied with a non-conducting expandable band. The resistance to flow of current through the potato was measured on each plug of the variety lots.

Moisture values were then determined by drying the same sample plugs in an air-oven for 24 hours at 105° F. The moisture content analyses were repeated with uncooked potato plugs. With these values, any change in moisture content of the tissue during the cooking process would be known.

Determination of chlorine. For the analysis of chlorine, the A.O.A.C. method *(1)* was generally followed, but a few changes in the official procedure were necessary for adaptation of the method to a plant product with a high content of carbohydrates. Each of the 10 samples of a variety consisted of one cylindrical potato plug sliced into discs of 1 mm. thickness. After weighing, the samples were transferred to acid-cleaned porcelain crucibles. The samples were moistened with 25 ml. of 5% Na_2CO_3 solution and slowly evaporated to dryness. It was found that the addition of 25 ml. of 5% Na_2CO_3 solution was necessary to prevent the loss of chlorine in ashing on a hot plate. Ashing was completed in two phases. First, the samples were ignited as thoroughly as possible at a temperature not exceeding dull redness (approximately 525° C.). Samples were then cooled, extracted with hot demineralized water, filtered through a 9 cm. Whatman No. 44 filter paper and washed. Filtrates were collected in 100-ml. volumetric flasks. Filter papers and residues were returned to the respective crucibles and ignited to ash. Each ashed sample was dissolved in 20 ml. of a one-to-four dilution of HNO_3, filtered through a 9 cm. Whatman No. 44 filter paper, and washed thoroughly with hot demineralized water. Filtrates from the second extraction were added to respective filtrates from the first extraction, and diluted with demineralized water to 100 ml.

To the prepared sample solutions, 3 ml. of 5% $AgNO_3$ were added. This quantity of $AgNO_3$ was found to be the proper amount to precipitate the chlorine anions in solution. Addition of more than 3 ml. would have resulted in more than an acceptable excess of $AgNO_3$. The treated solution was heated to 90° C. and allowed to stand 24 hours in the absence of light. After the AgCl was coagulated, samples were filtered through prepared Gooch crucibles and washed with dilute HNO_3 acid until the washings were clear of $AgNO_3$. Precipitates were dried at 150° C., cooled, and weighed.

Viscosity measurements. Changes in viscosity of potatoes during the cooking period were determined by use of a Brookfield Viscometer. Ten samples were prepared of each variety. Each sample was composed of 150 g. of equal length cylindrical potato plugs. All samples were cooked in boiling distilled water. The ratio of water to potato was two to one. Samples of each variety were cooked 5, 7, 9, 10, 11, 12, 13, 14, and 15 minutes with a constant-rate hot plate. After each sample was cooked, drained, and air-cooled to room temperature, it was transferred to a Waring blender, and blended with 100 ml. of distilled water for 3 minutes. From the blender, the sample was transferred to a viscometer cup. Viscosity readings were

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taken after a 2-minute operating period which allowed the instrument to become stabilized. Dilution of the potato slurry was necessary to obtain viscosity values within the range of the instrument.

RESULTS AND DISCUSSION

Organoleptic tests. Texture scores were taken as the criterion for mealiness or sogginess. The total of the value assigned by the panel was taken as the texture score for each variety. The varieties are shown in order of degree of mealiness in Table 1. The highest possible total score would be 150 for the mealiest variety; and the lowest possible total score would be 50 for the soggiest variety.

TABLE 1

Texture scores of six potato varieties differing in specific gravity and chlorine values

Variety	Texture score [1]	Specific gravity	mg. Chlorine per 100 gram sample
Russet Burbank	127	1.0788	71.2
Kennebec	109	1.0716	21.8
Katahdin	101	1.0731	63.1
Sebago	96	1.0770	58.2
Red Pontiac	87	1.0598	29.5
Early Gem	80	1.0575	20.9
"r" with texture scores.		0.945**	

[1] Significant at the 1% level.

An F value of 12.4 was obtained from the analysis of variance of texture scores. This value was highly significant at the 1% level which would indicate that the differences in texture scores were due to varietal characteristics. High fluctuations might have been expected among the individual judgments; however, there was a majority and in some cases near unanimous agreement in the serving blocks.

The specific gravity values shown in Table 1 are average values of 4 lots of each variety. The variation in specific gravity among lots within each variety was very small. A significant relationship was indicated between the texture scores and specific gravity. This has been reported by numerous investigators *(3, 4)*.

Relation of chlorine content and texture. The chlorine values which are averages of ten determinations of each variety are shown in Table 1. It was reported in an earlier study *(6)* that some chlorine-containing fertilizers caused a reduction in the specific gravity of potatoes. If this were true, then it would be reasonable to believe that chlorine content of tubers was inversely related to texture.

The results of this study indicated that there was a direct relationship between chlorine content and texture score for Russet Burbank, Katahdin, and Sebago varieties grown on organic soil ($r = 0.97^{**}$). However, these same factors were inversely related when considering those varieties grown on sandy loam soil ($r = -0.83^{*}$). Because of the possible soil interaction in this study, the relation of chlorine and texture is uncertain. It is possible that chlorine is directly related to potato texture within the range of chlorine found in the organic soil in which the three varieties were grown. At an undetermined higher level, additional chlorine might have caused a reduction in specific gravity and texture score.

Relation of conductivity and moisture characteristics to texture. The data obtained in these studies are given in Table 2 together with the respective texture scores. Although there was a small variation in moisture content between varieties, this variation was not consistent with conductivity values. Additionally, no obvious association was found between conductivity and texture scores. Yet, to the taste, it appeared that a significant difference in moisture content did exist between cooked, mealy and soggy potato tissues. Evaluation of variations in bound and free water in relation to texture should be considered in future research.

TABLE 2

Conductivity, and moisture characteristics of potato tissue in relation to texture of six potato varieties

Variety	Texture score	Ohms resistance	Moisture content cooked plugs dry basis	Moisture content uncooked plugs dry basis	Moisture change during cooking
			%	%	%
Russet Burbank	127	5,300	88.07	77.41	+ 10.66
Kennebec	109	6,100	88.06	83.62	+ 4.44
Katahdin	101	5,080	85.12	78.08	+ 7.04
Sebago	96	5,400	87.65	79.55	+ 8.10
Red Pontiac	87	7,600	88.54	86.24	+ 2.3
Early Gem	80	6,300	88.05	86.10	+ 1.95
"r" with texture scores		0.554	−0.09	−0.72*	0.93**
"r" with specific gravity					0.94**

Data in Table 2 for moisture content of uncooked tissue did show some degree of association with texture scores as would be expected ($r = -0.72^{*}$). In this area of study, the most striking relationship with potato texture and specific gravity was the per cent increase of moisture content during the cooking process. The data indicated that tubers with higher texture scores and specific gravity values absorbed more water during the cooking process, yet resulted in a dry mealy texture.

Relation of potato slurry viscosities to quality. The results obtained from the viscosity measurements, texture scores, and specific gravities are shown in Figure 1. Characteristic relative viscosity changes during the heating period were found for each variety. Generally, with higher texture scores the samples gelatinized more rapidly and attained a higher maximum relative viscosity. The three varieties, Red Pontiac, Early Gem, and Kennebec, which had the lower specific gravities exhibited similar viscosity curves while those varieties of higher specific gravity exhibited less similar curves. These curves indicated that shortly after reaching the maximum relative viscosity, a marked reduction in viscosity occurred. This could be the result of excessive cell rupturing and escape of gelled starch.

The maximum relative viscosities were related to texture scores ($r = 0.791^{*}$), but they were found to be more closely correlated to specific gravity ($r = 0.89^{**}$). Although these relationships are significant, it is thought that more knowledge of the starch molec-

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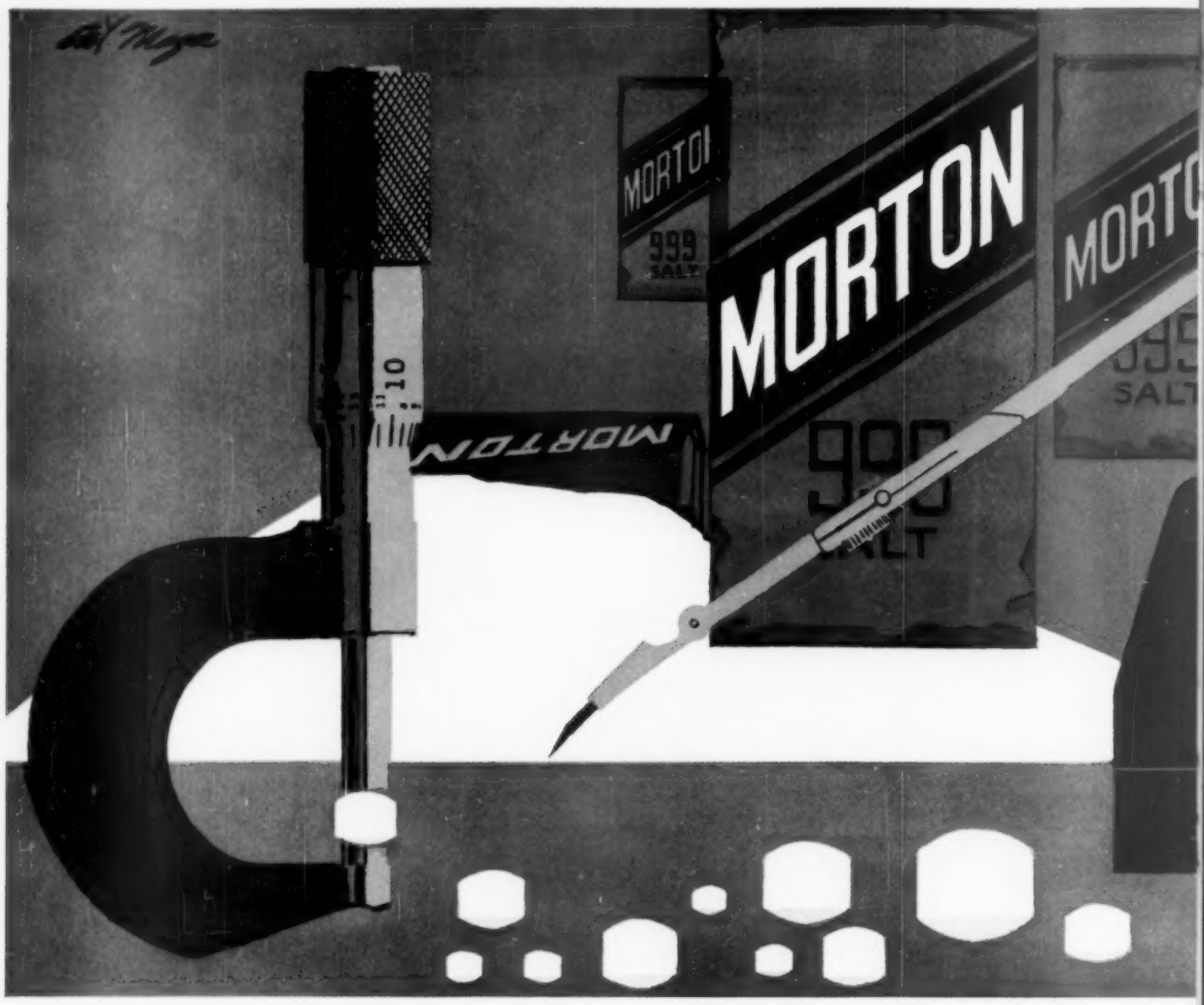

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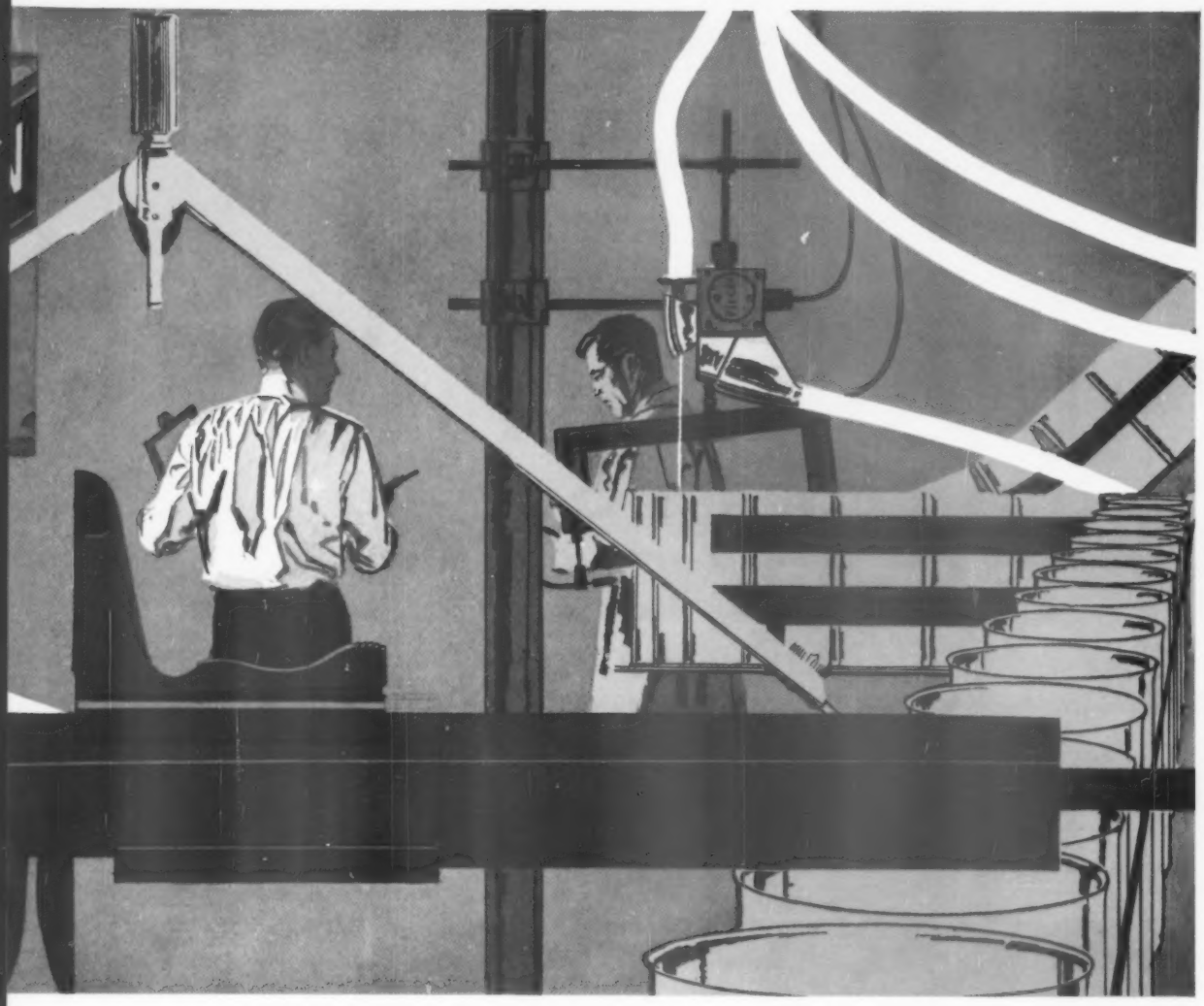

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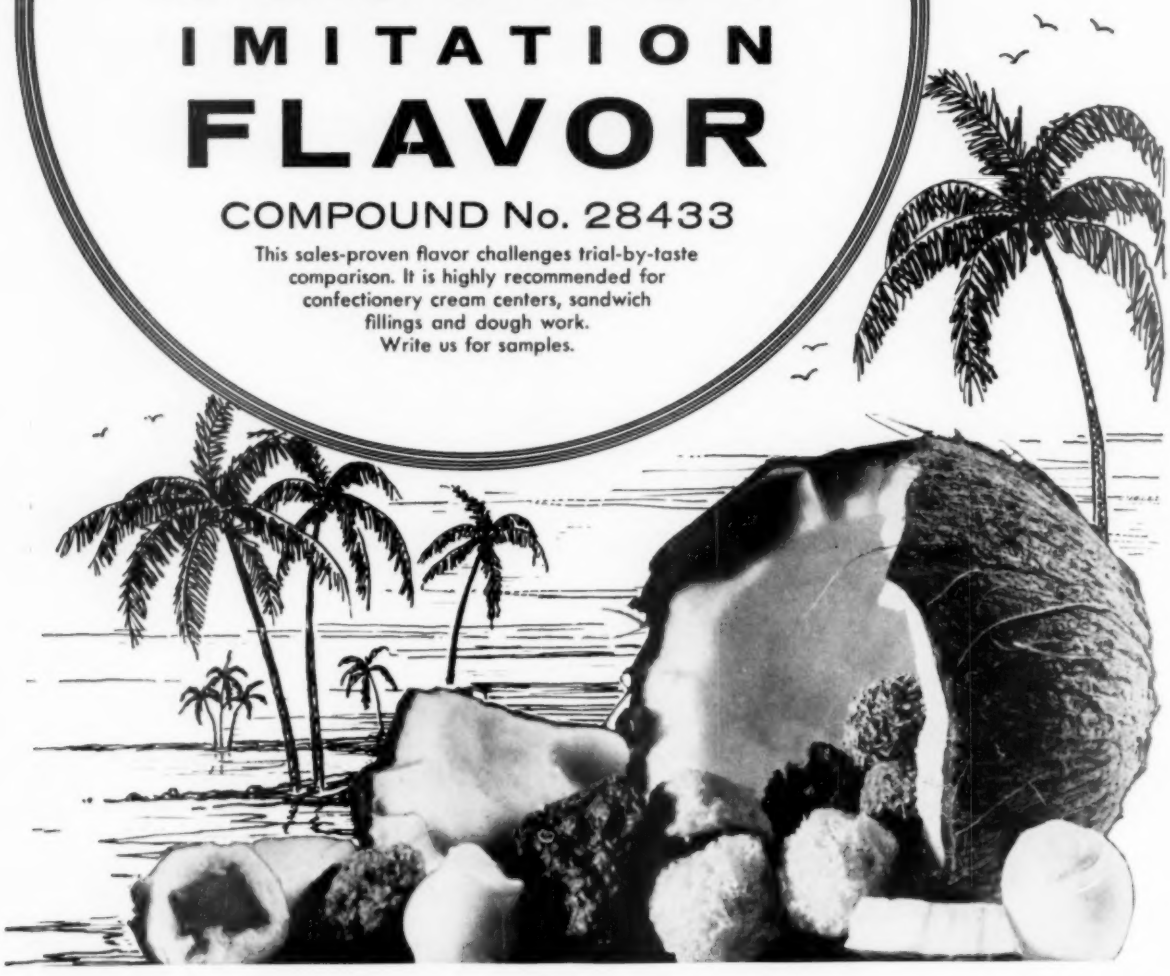

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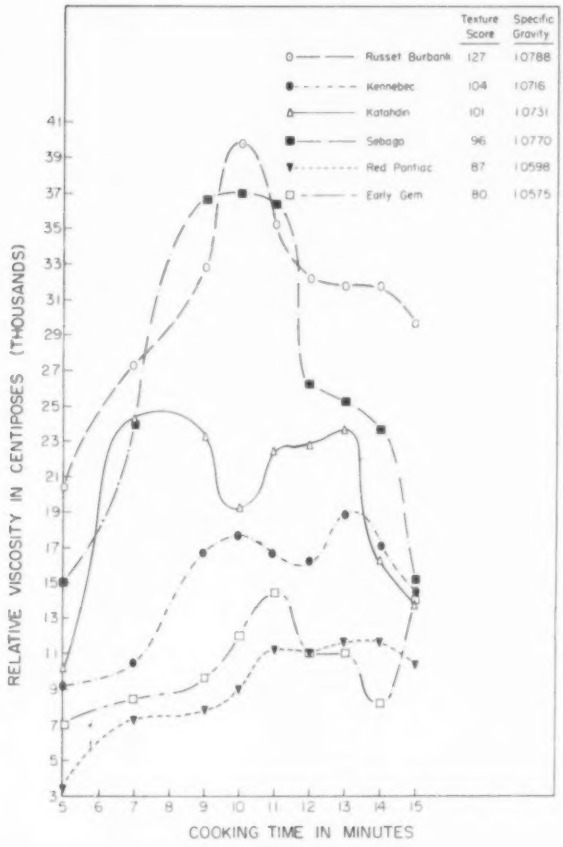

Figure 1.

ular structure and size is needed before the relation of starch and texture can be fully appreciated.

SUMMARY

Studies were made of the relation of six potato textures and specific gravities, conductivities, moisture contents, chlorine contents, and relative viscosities. The data indicated that the differences in texture scores were due to varietal characteristics.

As expected, texture scores were highly related to specific gravity. The relation of chlorine and texture is uncertain. Varieties grown on organic soil were directly related while those varieties grown on sandy loam soil were inversely related.

There was little relation between electrical conductivity values and texture scores, but the percent moisture gain during cooking was highly related to texture and specific gravity.

Tubers of higher specific gravity absorbed more water upon cooking yet possessed a dry mealy texture.

Maximum relative viscosities were related with texture scores but more highly related to specific gravity.

LITERATURE CITED

1. Association of Official Agricultural Chemists. *Methods of Analysis.* 8th ed., 1955. Washington, D. C.
2. Bettelheim, F. A., and Sterling, C. Factors associated with potato texture. I. Specific gravity and starch content. *Food Research*, 20, 71–80 (1955).
3. Blood, P. T., and Haddock, J. L. Variations in cooking quality of potatoes as influenced by fertilizers. *Am. Potato J.*, 16, 329–335 (1939).
4. Clark, C. F., Lombard, P. M., and Whiteman, E. F. Cooking quality of the potato as measured by specific gravity. *Am. Potato J.*, 17, 38–45 (1940).
5. Cochran, W. G., and Cox, G. M. *Experimental Designs.* 1st ed., 1950. J. Wiley and Sons, Inc. N. Y.
6. Dunn, L. E., and Nylund, R. E. The influence of fertilizers on the specific gravity of potatoes grown in Minnesota. *Am. Potato J.*, 22, 275–288 (1945).
7. Goldthwaite, N. E. Variations in the composition of Colorado potatoes. Colorado Agr. Expt. Sta. *Bull. 296* (1925).
8. Kirkpatrick, M. E. Cooking quality of potatoes, its evaluation and relationship to potato characteristics. *Am. Potato J.*, 30, 52–53 (Abstract) (1953).
9. LeCleRG, E. L. Association of specific gravity with dry-matter content and weight of Irish potato tubers. *Am. Potato J.*, 24, 6–9 (1947).
10. Smith, O. Some factors affecting culinary quality of potatoes. *Am. Potato J.*, 14, 221–224 (1937).
11. Unrau, A. M., and Nylund, R. E. The relation of physical properties and chemical composition to mealiness in the potato. I. Physical properties. *Am. Potato J.*, 34, 245–253 (1957).

Trimming Time and Yield Factors in Processing of Apple Slices

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(Manuscript received August 23, 1958)

In a previous paper *(3)* a report was presented on processing of applesauce. Background information was given on the development of the apple processing industry, and the objectives of the research work were discussed. The present report gives results obtained in similar work on apple slices.

EXPERIMENTAL

Experiment I. The experiment was conducted during the 1954 and 1955 processing seasons. The apples used in this experiment were of the four more common processing varieties in the Appalachian area: York Imperial, Golden Delicious, Stayman, and Grimes Golden. Recovery data were taken for each variety separately. A complete and separate experiment was run in each of 3 apple slices processing plants, all located in Virginia.

Apples of each variety, of maturity usually regarded as optimum for processing, were taken either from cold storage, from grower packhouses, or from the processing plant production line. The apples were sized into 3 sizes, 2¼ in. to 2½ in., 2½ in. to 2¾ in., and 2¾ in. and up in diameter. The apples in each size were graded by Federal-State fresh fruit inspectors into U. S. No. 1 and U. S. No. 2 apples, using the U.S.D.A. Grades of Apples for Processing *(4)*. Culls were not used for the work reported here. There were, then, 6 different grade-size classifications. After grading, the apples were held in cold storage (32° F., 0° C.) until processed. The holding time was not more than one week in any one case. From one to 20 samples weighing approximately 40 lbs. each were prepared for each grade-size classification in each plant, depending upon the availability of the different sizes and grades of fruit. Four varieties of apples were sampled in the 3 processing plants. Each one of these 40 lb. samples was run separately through a mechanical peeler-corer operated by the plant being studied. The peelers used were F. B. Pease units. In one of the plants a one-cup peeler was used, while in the other two plants, the peelers were of the three-cup type. The peeled and cored fruit was trimmed by personnel regularly working on the production line, but transferred temporarily to the experimental machine. After trimming, the apples were mechanically sliced, and the screenings (chips) separated from the slices by hand screening through a ¾ inch mesh screen. Apples of sizes 2¾ in. in diameter and up were sliced into 16 sections; apples of sizes between 2¼ and 2¾ in. in diameter were sliced into 12 sections. Records were made of (a) the weight of the peel and core waste; (b) total trim waste; (c) screenings; and (d) the weight of the whole peeled, cored, trimmed and sliced apples.

Experiment II. Because of some question as to the validity of a 40 lb. sample being representative of commercial conditions in time and recovery studies, and because certain refinements in measuring recovery were indicated from analysis of the 40 lb. sample data, it was felt desirable to perform a second experiment under commercial conditions as a check against the first experiment and to answer other questions raised by the industry since the beginning of the first experiment.

Four Virginia and Pennsylvania processors[a] agreed to cooperate with the Virginia Agricultural Experiment Station in running pre-graded and pre-sized lots of apples through their regular production line during the 1957 processing season. Screening was the only operation for which regular production line equipment was not used. A one-half inch mesh vibrating screen was used for this purpose. In two of the 4 plants, two four-cup F. B. Pease peelers were employed, while in the other two plants, three-cup F. B. Pease peelers were used. The apples were obtained from growers that usually supply fruit to the plant at which the work was to be done. Apples of the York Imperial variety and of maturity considered optimum for processing were used.

On the basis of previous experience (Experiment I), the size of the lots was adjusted so that each lot would require approximately 45 to 60 minutes of plant operation. Three size classifications of U .S. No. 1 and U. S. No. 2 grades (2¼ in. to 2½ in., 2½ in. to 2¾ in., and 2¾ in. and up in diameter) were run in each plant. The fruit was graded by Federal-State fresh fruit inspectors. The weight of the sample run for each lot (grade-size classification) ranged from 300 to 2300 lbs. The mean weight was 1170 lbs.

For this experiment, apples in each lot were weighed and automatically counted as they were peeled. The peeling, coring, and trimming time was recorded. Peels and cores (mechanical waste), the trimmings, screenings, and the peeled, cored, trimmed, and sliced apples were weighed separately. Also a 15-lb. sample was taken from the trim waste that was produced by each size and grade classification. The defect trim and the peel trim of this 15-lb. sample were separated and weighed in order to determine the proportion of defect trim and of peel trim in the total trim.

Although all of the cooperating plants used the same make of mechanical peelers, there was considerable variation in the ways the machines were adjusted at the various plants. One plant would adjust the peeling knife deep enough to remove some defects along with the peel, whereas another plant would remove only the skin of the apples and depend upon the trimmers to remove the defects by hand trimming. Other variations also occurred between plants which made direct comparisons of results invalid. The statistical methods used in the analysis of results allow for plant-to-plant differences resulting from unmeasured factors when determining relationships between the factors measured.

RESULTS AND DISCUSSION

Table 1 shows recovery data for Experiment I. There were no significant differences among varieties for yield of prepared apples, screenings, peel and core waste, or trim waste for apples of Grade U. S. No. 1 for Processing. The larger sizes of apples of all varieties yielded a greater percentage of prepared

[a] Different codes have been used for each processing plant throughout the text in order to make plant identification impossible.

TABLE 1

Average recovery values[1] for processing apple slices from different sizes and grades of York Imperial, Grimes Golden, Stayman, Golden Delicious, and Jonathan varieties of apples

Variety: York Imperial

	Grade U. S. 1						Grade U. S. 2					
	2¼"–2½"		2½"–2¾"		2¾" and Up		2¼"–2½"		2½"–2¾"		2¾" and Up	
Number of approx. 40-lb. samples run in each of three processing plants	4, 10, 12		4, 10, 11		4, 10, 10		4, 5, 3		4, 10, 6		4, 17, 16	
Prepared[2] apple slices (per cent[3])	53.2[4]	.83[5]	61.5	.95	64.4	1.00	48.2	.75	56.2	.87	59.9	.93
Chips[6]	7.0	1.6	5.1	1.1	4.5	1.00	6.1	1.4	5.4	1.2	4.4	.98
Peels and cores (per cent[3])	29.5	1.4	25.8	1.2	21.3	1.00	30.8	1.4	25.2	1.2	21.2	1.0
Total trim[7] (per cent[3])	9.2	.86	6.1	.57	10.7	1.00	14.0	1.3	12.5	1.2	14.0	1.3
Total waste (per cent[3])	38.7	1.2	31.9	1.0	32.0	1.00	44.8	1.4	37.7	1.2	35.2	1.1
Number of apples per 100 lbs. of fresh fruit	493	2.0	379	1.5	257	1.00	498	2.0	377	1.5	258	1.0

Variety: Golden Delicious

	Grade U. S. 1						Grade U. S. 2					
	2¼"–2½"		2½"–2¾"		2¾" and Up		2¼"–2½"		2½"–2¾"		2¾" and Up	
Number of approx. 40-lb. samples run in each of three processing plants	4, 0, 7		4, 7, 3		4, 12, 10		4, 0, 7		4, 0, 4		4, 0, 12	
Prepared[2] apple slices (per cent[3])	56.7[4]	.83[5]	63.0	.92	68.3	1.00	57.5	.84	67.0	.98	65.7	.96
Chips[6]	4.9	1.2	4.4	1.1	4.1	1.00	4.8	1.2	3.9	.95	3.2	.78
Peels and cores (per cent[3])	26.2	1.2	26.1	1.2	21.6	1.00	25.3	1.2	22.9	1.1	21.6	1.0
Total trim[7] (per cent[3])	11.4	2.2	5.3	1.0	5.2	1.00	11.6	2.2	10.6	2.0	8.9	1.7
Total waste (per cent[3])	37.6	1.4	31.4	1.2	26.7	1.00	36.9	1.4	33.5	1.3	30.5	1.1
Number of apples per 100 lbs. of fresh fruit	489	1.9	381	1.5	262	1.00	517	2.0	388	1.5	268	1.0

Variety: Grimes Golden

	Grade U. S. 1						Grade U. S. 2					
	2¼"–2½"		2½"–2¾"		2¾" and Up		2¼"–2½"		2½"–2¾"		2¾" and Up	
Number of approx. 40-lb. samples run in one processing plant	12		13		11		10		10		13	
Prepared[2] apple slices (per cent[3])	57.0[4]	.81[5]	67.0	.95	70.4	1.00	47.1	.67	56.5	.80	59.2	.84
Chips[6]	6.3	1.4	5.0	1.1	4.6	1.00	7.4	1.6	7.5	1.6	7.2	1.6
Peels and cores (per cent[3])	32.6	1.5	26.3	1.2	21.9	1.00	32.7	1.5	26.5	1.2	22.1	1.0
Total trim[7] (per cent[3])	2.8	1.9	.3	.2	1.5	1.00	10.7	7.1	8.1	5.4	10.4	7.0
Total waste (per cent[3])	35.3	1.5	26.5	1.1	23.4	1.00	43.4	1.9	34.6	1.5	32.5	1.4
Number of apples per 100 lbs. of fresh fruit	480	1.8	370	1.4	270	1.00	484	1.8	378	1.4	279	1.0

Variety: Stayman

	Grade U. S. 1						Grade U. S. 2					
	2¼"–2½"		2½"–2¾"		2¾" and Up		2¼"–2½"		2½"–2¾"		2¾" and Up	
Number of approx. 40-lb. samples run in each of two processing plants	13 and 4		9 and 4		13 and 4		9 and 4		13 and 4		10 and 4	
Prepared[2] apple slices (per cent[3])	50.6[4]	.76[5]	59.7	.89	66.9	1.00	42.5	.64	52.0	.78	56.6	.85
Chips[6]	8.9	1.7	6.3	1.2	5.2	1.00	9.8	1.9	7.9	1.5	6.3	1.2
Peels and cores (per cent[3])	32.7	1.5	27.1	1.2	21.9	1.00	33.6	1.5	27.8	1.3	22.6	1.0
Total trim[7] (per cent[3])	6.2	1.4	5.2	1.2	4.5	1.00	12.5	2.8	12.6	2.8	13.5	3.0
Total waste (per cent[3])	38.9	1.5	32.3	1.2	26.4	1.00	46.1	1.7	40.4	1.5	36.1	1.4
Number of apples per 100 lbs. of fresh fruit	470	2.0	363	1.6	232	1.00	496	2.1	397	1.7	249	1.1

Variety: Jonathan

	Grade U. S. 1						Grade U. S. 2					
	2¼"–2½"		2½"–2¾"		2¾" and Up		2¼"–2½"		2½"–2¾"		2¾" and Up	
Number of approx. 40-lb. samples run in one processing plant	3		7		10		None		None		None	
Prepared[2] apple slices (per cent[3])	53.0[4]	.80[5]	64.2	.97	66.4	1.00						
Chips[6]	6.5	1.4	5.1	1.1	4.7	1.00						
Peels and cores (per cent[3])	33.3	1.5	26.7	1.2	22.5	1.00						
Total trim[7] (per cent[3])	5.4	1.7	2.3	.74	3.1	1.00						
Total waste (per cent[3])	38.7	1.5	29.0	1.1	25.6	1.00						
Number of apples per 100 lbs. of fresh fruit	508	1.7	386	1.3	292	1.00						

[1] All values are weighted based on number of sample runs in each plant.

[2] Prepared apples are peeled, cored, trimmed and sliced apples.

[3] Per cent of fresh fruit.

[4] Actual values obtained in experimental work.

[5] Ratio of value found to value for size 2¾ in. and Up in Grade U. S. 1.

[6] Broken slices, pieces smaller than ½ in.

[7] Total trim is that waste that results when defects and peel left after mechanical peeling are removed.

product than the smaller sizes. Also, apples of all varieties of Grade U. S. No. 1 for Processing yielded more prepared product than fruit of Grade U. S. No. 2. The amount of peel and core removed as a per cent of weight of fresh fruit increased as size decreased, and also showed a tendency to increase with declining quality. The percentage chips screened out had a tendency to decrease as size increased, both for U. S. 1 and U. S. 2 apples.

Table 2 shows time and recovery data for Experiment II. A significant difference in yield of slices was observed among sizes and between grades. The yield of the larger sizes of apples and that of U. S. No. 1 grade fruit was larger than the yield of the smaller sizes and U. S. No. 2 grade apples. There was a consistent reduction in peel and core waste as size of apples increased. When plant differences were taken into account by covariance analysis, a significant difference in peel and core waste was found between the 2¼ in.–2½ in. in diameter apples and the larger sizes. No significant differences were found between the sizes 2½ in.–2¾ in. and up inches in diameter. There were no significant differences in peel trim or defect trim among sizes, and in peel trim between grades. However, there were significant differences in defect trim between grades. No significant differences were observed in broken slices between grades. There were significant differences among sizes. In trimming time significant differences were observed both between grades and among sizes.

In Table 2, differences occurring among plants were not taken into consideration. Therefore, the average deviations of the observations are somewhat greater than the actual deviations when differences among plants are taken into account by covariance analysis. Table 2 is included for the purpose of showing actual average plant data. Data obtained at individual plants is not being disclosed in a way that would permit the identification of individual plant data.

Differences existing among plants make direct comparisons of plant data invalid. The method followed in Experiment II was too expensive to allow the replication of samples needed, in order to analyze each plant's data separately. Therefore, a statistical method of covariance analysis, known as differential contrast *(1)*, has been used. This method allows pooling of observations from all plants in determining, by regression, relationships between the continuous variables, while accounting for variability among plants caused by discrete and unmeasured variables. The authors utilized these statistical methods using the data obtained at the processing plants to develop the equations presented in this paper.

Figure 1 is based on actual plant data from the experimental lots showing the proportion of total trim waste made up of defect trim and of peel trim, respec-

TABLE 2

Time and recovery value for processing apple slices from the York Imperial variety of apples. Average values from four processing plants

	Grade U. S. 1					
	2¼"–2½"		2½"–2¾"		2¾" and Up	
Prepared[1] apple slices (per cent[2])	56.8 ± 4.1[3]	.90[4]	61.2 ± 2.5	.98	62.7 ± 3.4	1.00
Peels and cores (per cent[2])	27.8 ± 4.0	1.14	24.6 ± 1.9	1.01	24.4 ± 2.3	1.00
Peel trim (per cent[2])	2.9 ± .7	1.48	2.3 ± .5	1.19	1.9 ± .5	1.00
Defect trim (per cent[2])	2.1 ± 1.5	.80	2.7 ± 1.4	1.01	2.7 ± 1.4	1.00
Broken slices per cent[2]	8.1 ± 2.1	1.70	6.0 ± 1.8	1.26	4.7 ± .8	1.00
Unaccountable waste (per cent[2])	2.4 ± 1.9	.69	3.3 ± 2.9	.94	3.5 ± 1.9	1.00
Total waste (per cent[2])	40.9 ± 5.1	1.21	35.5 ± 3.3	1.05	33.8 ± 3.2	1.00
Number of apples per 100 lbs. of fresh fruit	504 ± 13	1.85	380 ± 18	1.40	272 ± 10	1.00
Trimming time per 100 lbs. of fresh fruit (minutes[5])	31.8 ± 3.1	1.58	26.1 ± 4.3	1.29	20.1 ± 3.1	1.00
Trimming time per 100 lbs. of prepared apple slices (minutes[5])	56.9 ± 9.1	1.76	43.1 ± 8.8	1.33	32.3 ± 5.6	1.00
Average quantity of fresh apples used at each plant	1035 lbs.		1199 lbs.		1755 lbs.	

	Grade U. S. 2					
	2¼"–2½"		2½"–2¾"		2¾" and Up	
Prepared[1] apple slices (per cent[2])	51.1 ± 6.0	.81	54.9 ± 4.0	.87	58.9 ± 3.3	.94
Peels and cores (per cent[2])	28.6 ± 3.8	1.17	26.4 ± 3.4	1.08	25.1 ± 3.2	1.03
Peel trim (per cent[2])	3.8 ± .5	1.93	2.6 ± .7	1.35	2.8 ± .9	1.44
Defect trim (per cent[2])	6.6 ± 3.2	2.49	7.8 ± 2.9	2.93	6.2 ± 2.2	2.32
Broken slices per cent[2]	8.3 ± 2.0	1.75	6.6 ± 1.3	1.40	5.0 ± 1.0	1.06
Unaccountable waste (per cent[2])	1.6 ± 1.1	.46	1.7 ± 1.2	.49	2.0 ± .2	.57
Total waste (per cent[2])	47.3 ± 5.5	1.40	43.4 ± 5.1	1.29	39.1 ± 3.3	1.16
Number of apples per 100 lbs. of fresh fruit	518 ± 14	1.90	380 ± 16	1.40	264 ± 18	.97
Trimming time per 100 lbs. of fresh fruit (minutes[5])	41.3 ± 9.8	2.05	36.2 ± 6.9	1.80	24.7 ± 5.7	1.23
Trimming time per 100 lbs. of prepared apple slices (minutes[5])	83.7 ± 23.2	2.59	67.5 ± 15.4	2.09	42.2 ± 8.9	1.31
Average quantity of fresh apples used at each plant	707 lbs.		919 lbs.		1403 lbs.	

[1] Prepared apples are peeled, cored and trimmed apples.
[2] Per cent of fresh fruit.
[3] Average deviation.
[4] Ratio of value found to value for size 2¾ in. and Up in Grade U. S. No. 1.
[5] Time is expressed as minutes required by one worker.

tively. In no case was the defect trim fraction of total trim for U. S. No. 1 apples as high as the maximum tolerance allowed for defect trim in the grade. In 5 instances out of 12, defect trim removals in the U. S. No. 2 grade were below the maximum tolerance for the U. S. No. 1 grade.

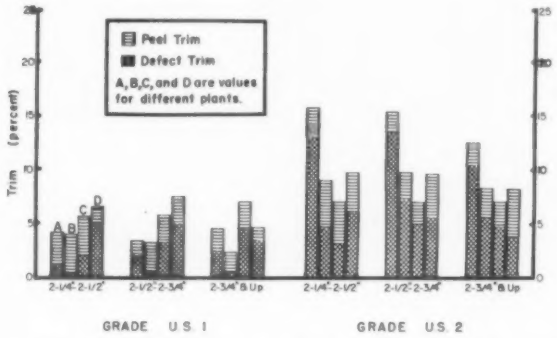

Figure 1. Per cent trim of apples of different grades and sizes observed at four processing plants.

Figure 2 shows the effect that size of apples had on (a) per cent of peels and cores, (b) per cent recovery of prepared product (peeled, cored, trimmed, and sliced apples), and (c) screenings, as found in 4 canned apple slices processing plants. In order to show only the effect of size of apples on the 3 dependent fractions, the per cent trim waste was held constant for all plants in all size classes at the average of the four plants, even though the level of trim waste varied widely between plants.

Differences in yield among plants resulted from differences in intercepts, per cent broken slices, and per cent peels and cores among plants. Variations in peels and cores resulting from differences in policy in regard to type of knives used in peeling and thickness of peel removed was the greatest cause of variation in yield among plants. Some plant managers have the apples peeled quite heavily to remove some of the defects along with the peel; others peel lightly and depend on trimmers to remove defects. Some peeling machines were equipped with knives that removed peels from the calyx and stem end of the apples; others were not equipped to do this. Differences in core size removed in different size classes of apples also varied among plants.

In the samples of apples from the 4 plants upon which Figure 2 is based, apples of size 2¾ in. and up in diameter averaged 268 apples per 100 lbs., apples in size class 2½ in. to 2¾ in. in diameter averaged 380 apples per 100 lbs., and apples in size class 2¼ in. to 2½ in. in diameter averaged 511 apples per 100 lbs. However, in order to make it possible to better compare results with those obtained in similar work on applesauce *(3)*, Figure 2 has been based on 263, 424, and 530 apples per 100 lbs. of fruit, respectively, for the 3 sizes.

The values in Figure 2 are based on the following 3 regression equations:

$$\hat{Y} = 25.60 + P_i + S_i \pm .0140\, d_{\bar{s}_i} \qquad (1)$$

where:

$\hat{Y}$ = Peels and cores (per cent)

P_i = Plant differential (P_A is included in the intercept)

S_i = Size differential (S_i is included in the intercept)

$d_{\bar{s}_i}$ = The differential in apples per 100 lb. from the average number of apples per 100 lb. in the size group.

This equation had an R^2 value of .8254 and was significant at the 1% level. Plant differences accounted for approximately 83% of the R^2 value and size class differences accounted for approximately 17%. The intercept term in the estimating equations includes, in addition to the value of Y when X equals zero, the value of Y for the basic classes of discrete classifying variables. Other classes of discrete variables (plant, size, grade) have differential values of Y from the intercept value shown for the basic class.

$$\hat{Y} = 7.32 + P_i + S_i + .0508X_1 \pm .0133\, d_{\bar{s}_i} \qquad (2)$$

where:

$\hat{Y}$ = Broken slices and seed cells (per cent)

P_i = Plant differential (P_A included in the intercept)

S_i = Size differential (S_i included in the intercept)

X_1 = Total trim waste (per cent)

$d_{\bar{s}_i}$ = Differential in apples per 100 lb. from the average number of apples per 100 lb. in the size group.

This equation had an R^2 value of .8936 and was significant at the 1% level. Plant differences accounted for 57% of the R^2 value and size class differences accounted for 42%. The total trim regression value was not significant at the 5% level of significance and accounted for only 1% of the R^2 value.

$$\hat{Y} = 94.26 + P_i - .9715X_1 - .8929X_2 - .9202X_3 \qquad (3)$$

where:

$\hat{Y}$ = Prepared apple slices (per cent)

P_i = Plant differential (P_A included in the intercept)

X_1 = Peel and core waste (per cent)

X_2 = Total trim waste (per cent)

X_3 = Broken slices and seed cell waste (per cent)

This equation had an R^2 value of .9346 and was significant at the 1% level. Plant differences accounted for 40% of the R^2 value, peel and core waste for 32%, total trim for 25%, and broken slices and seed cells for 3%. All continuous variable regression values were significant at the 99% level of significance.

Plant differences are of course much more influential on yield variation than equation (3) indicates, in as much as they were responsible to a large degree for the levels of peel and core and broken slices included as continuous variables in equation (3).

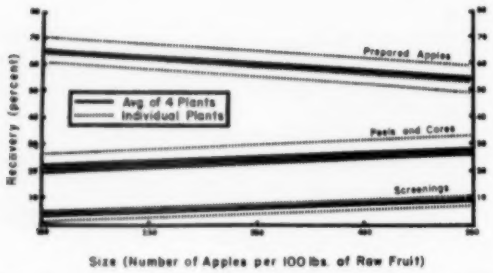

Figure 2. E-ect of size of apples on per cent recovery of prepared apples, peels and cores, and of screenings.

Values in Figure 3 are based on the following two regression equations, (4) and (5):

$$\hat{Y} = 4.30 + P_i + S_i + G_i \pm .0036 d_{\bar{S}_i} \qquad (4)$$

where:

$\hat{Y}$ = Total trim waste (per cent)

P_i = Plant differential (plant A is included in the intercept)

S_i = Size differential (S_1 is included in the intercept)

G_i = Grade differential (G_1 is included in the intercept)

$d_{\bar{S}_i}$ = Differential for size in apples per 100 lb. variation from apples per 100 lb. in the sample.

The equation had an R^2 value of .6265 which was significant at the 1% level of significance. Plant differences accounted for 19% of the R^2 value, size difference for 2%, and grade difference for 79%.

Total trim removed from U. S. No. 1 grade apples was from 50 to 54% of the total trim removed from U. S. No. 2 apples when results from the four plants were averaged after trim was adjusted for size differences in the different plants. The range between plants and sizes of apples was from 3.45% for apples 2¾ in. and up in diameter in one plant to 7.08% for apples 2¼ in.–2½ in. in diameter in another plant. In all plants the ratio of per cent trim from U. S. No. 1 grade apples to per cent trim from U. S. No. 2 grade apples became less as the apple size increased.

$$\hat{Y} = .89 + P_i + S_i + G_i \pm .0057\ d_{\bar{S}_i} \qquad (5)$$

where:

$\hat{Y}$ = Defect trim (per cent)

P_i = Plant differential (Plant A is included in the intercept)

S_i = Size differential (S_1 is included in the intercept)

G_i = Grade differential (G_1 is included in the intercept)

$d_{\bar{S}_i}$ = Differential for apples for 100 lb. variation from apples per 100 lb. in the sample.

This equation had an R^2 value of .5445 which was significant at the 5% level of significance. Plant differences accounted for 32% of the R^2 value, size differences for 1%, and grade differences for 67%.

Defect trim removed from U. S. No. 1 apples was from 38 to 49% of the defect trim removed from the U. S. No. 2 when results from the 4 plants were averaged after having adjusted for size differences between plants. The range between plants and sizes of apples was from .80% for 2¼ in. apples in one plant to 6.02% for 2¾ in. and up apples in another plant. In all plants the ratio of per cent defect trim from U. S. No. 1 grade apples to per cent trim from U. S. No. 2 grade apples became greater as apple size increased.

The quality of the apples within a grade could vary widely among plants and did vary especially in the U. S. No. 2 grade, which accounts for the small proportion of both total and defect trim accounted for by plant, size and grade differences.

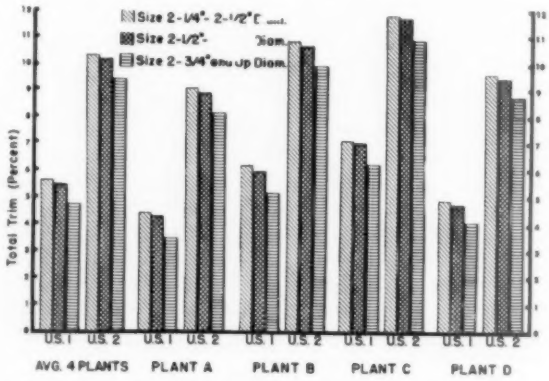

Figure 3. Effect of grade and size on per cent total trim in four processing plants.

Figure 4 values are based on the regression equation:

$$\hat{Y} = 35.12 + P_i + S_i + 1.6835 X_1 \qquad (6)$$

where:

$\hat{Y}$ = Minutes to trim 100 lb. of apples

P_i = Plant differentials (P_A is included in the intercept)

S_i = Size class differential (S_1 is included in the intercept)

X_1 = Defect trim (per cent)

The equation has an R^2 value of .8887 and is significant at the 1% level of significance. Plant differences accounted for 28% of the R^2 values, size differences for 46%, and defect trim differences for 26%. All regression values were significant at the 99% level of significance. Defect trim variations accounted for half of the total variance in trimming time in the samples in the study.

In Figure 5, the line representing apples 2¾ in. and up in diameter lies approximately 8 minutes below the line representing apples 2½ in. to 2¾ in. in diameter. The line representing apples 2¼ in. to 2½ in. in diameter lies approximately 8.5 minutes

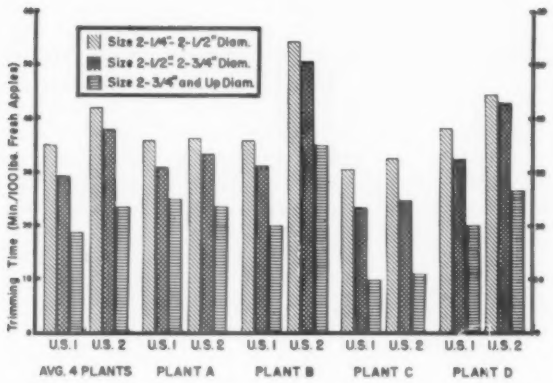
Size 2-1/4"- 2-1/2" Diam.
Size 2-1/2"- 2-3/4" Diam.
Size 2-3/4" and Up Diam.
Trimming Time (Min./100 lbs. Fresh Apples)
U.S.1 U.S.2 U.S.1 U.S.2 U.S.1 U.S.2 U.S.1 U.S.2 U.S.1 U.S.2
AVG. 4 PLANTS
PLANT A
PLANT B
PLANT C
PLANT D

Figure 4. Effect of grade and of size on trimming time in four processing plants. Trimming time is expressed as minutes requirde by one worker.

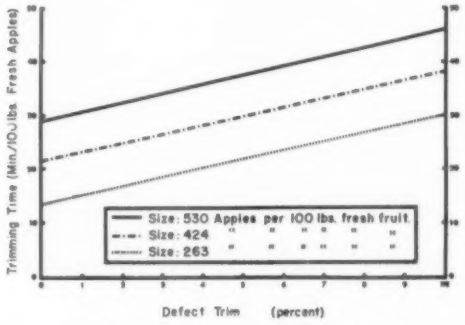

Figure 5. Relationship between defect trim and trimming time for apples of different sizes. Trimming time is expressed as minutes required by one worker.

above the line for apples 2½ in. to 2¾ in. in diameter. The difference between the lines is due to differences in both per cent peel trim and per cent defect trim. In order to make it possible to better compare results with those obtained in similar work on applesauce *(3)*, Figure 5, the same as Figure 2, has been based on 263, 424, and 530 apples per 100 lb. of fruit for the 3 sizes.

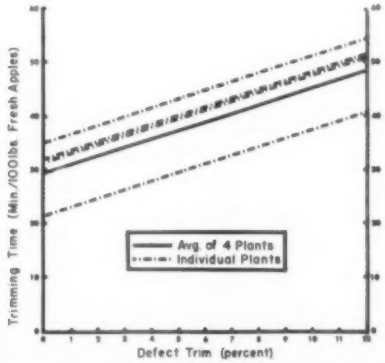

Figure 6. Relationship between defect trim and trimming time observed at four processing plants. Trimming time is expressed as minutes required by one worker.

In Figuure 6, the difference between the lines representing the different plants is due to intercept differences between plants, and to differences in total trim and in defect trim.

Tables 3 through 7 show the regression coefficients, standard errors and per cent determination coefficients for equations 1, 2, 3, 4, 5, and 6, respectively.

TABLE 3

Regression coefficients, standard errors, and the coefficient of determination in estimating per cent peels and cores waste

Item	Constant	Regression coefficient	Standard error
Intercept	A'	25.60**	.51
Plant B	P_B	1.32*	.58
Plant C	P_C	.52 N.S.	.58
Plant D	P_D	7.76**	.58
Size 2¾ in. and up	S_1	−3.35**	.51
Size 2½ in.–2¾ in	S_2	−2.82**	.53
Total error	....	....	.0290
Coefficient of determination	R^2	.9254**	....

N.S. = Not significant at 5% level with 59 degrees of freedom.
* = Significant at 5% level with 59 degrees of freedom.
** = Significant at 1% level with 59 degrees of freedom.

TABLE 4

Regression coefficients, standard errors, and coefficient of determination in estimating per cent broken slices

Item	Constant	Regression coefficient	Standard error
Intercept	A'	7.32**	.31
Plant B	P_B	−1.80**	.27
Plant C	P_C	+2.19**	.27
Plant D	P_D	+1.57**	.27
Size 2¾ in. and up	S_1	−3.23**	.23
Size 2½ in.–2¾ in	S_2	−1.81**	.24
Per cent total trim	X_1	+ .0508 N.S.	.0306
Differential for size	d_{S_1}	.0133	....
Total error	....	....	.0057
Coefficient of determination	R^2	.8936**	....

N.S. = Not significant at 5% level with 58 degrees of freedom.
** = Significant at 1% level with 58 degrees of freedom.

TABLE 5

Regression coefficients, standard errors and coefficient of determination in estimating yield of prepared slices

Item	Constant	Regression coefficient	Standard error
Intercept	A'	94.26**	2.53
Plant B	P_B	2.95*	.73
Plant C	P_C	.54 N.S.	.72
Plant D	P_D	2.25*	1.02
Peel and core (per cent)	X_1	.9715**	1.34
Total trim (per cent)	X_2	.8929**	.0676
Broken slices (per cent)	X_3	.9202**	.1916
Total error	....	....	.0027
Coefficient of determination	R^2	.9346**	....

N.S. = Not significant at 5% level with 58 degrees of freedom.
* = Significant at 5% level with 58 degrees of freedom.
** = Significant at 1% level with 58 degrees of freedom.

Equations (1) to (6) may be used in determining differential costs of peeling and trimming apples of different size and quality by using the same method as was used in determining differential costs of peeling and trimming apples for applesauce *(2)*.

TABLE 7

Regression coefficients, standard errors, and coefficients of determination in estimating defect trim

Item	Constant	Regression coefficient	Standard error
Intercept	A′	.89 N.S.	.94
Plant B	P_B	1.46 N.S.	.83
Plant C	P_C	3.75**	.83
Plant D	P_D	.61 N.S.	.83
Size 2½ in.–2¾ in.	S_2	.38 N.S.	.76
Size 2¾ in. and up	S_3	1.41 N.S.	.73
Grade U. S. No. 2	G_2	3.87**	.94
Grade A	G_A	−.73 N.S.	.94
Grade B	G_B	2.24*	.94
Grade C	G_C	4.13**	.94
Total error	....	....	.0577
Coefficient of determination	R^2	.5445**	....

N.S. = Not significant at the 5% level with 55 degrees of freedom.
* = Significant at the 5% level with 55 degrees of freedom.
** = Significant at the 1% level with 55 degrees of freedom.

TABLE 6

Regression coefficients, standard errors, and coefficient of determination in estimating total trim waste

Item	Constant	Regression coefficient	Standard error
Intercept	A′	4.30**	.85
Plant B	P_B	1.81*	.85
Plant C	P_C	2.77**	.85
Plant D	P_D	.65 N.S.	.85
Size 2½ in.–2¾ in.	S_2	−.15 N.S.	.69
Size 2¾ in. and up	S_3	−.89 N.S.	.66
Grade U. S. No. 2	G_2	4.68**	.75
Grade A	G_A	−.52 N.S.	.75
Grade B	G_B	2.90**	.75
Grade C	G_C	5.01**	.85
Differential for size	d_{S_1}	.0036	....
Total error	....	....	.0475
Coefficient of determination	R^2	.6265*	....

N.S. = Not significant at 5% level with 55 degrees of freedom.
* = Significant at 5% level with 55 degrees of freedom.
** = Significant at 1% level with 55 degrees of freedom.

TABLE 8

Regression coefficients, standard errors, and coefficient of determination in estimating trimming time per 100 pounds fresh apples

Item	Constant	Regression coefficient	Standard error
Intercept	A′	35.12**	1.25
Plant B	P_B	−14.47**	1.23
Plant C	P_C	−3.59**	1.38
Plant D	P_D	.8887**	1.27
Size 2¾ in. and up	S_3	−3.21*	1.12
Size 2½ in.–2¾ in.	S_2	−15.75**	1.17
Per cent defect trim	X_1	−7.89**	.1541
Differential for size	d_{S_1}	1.6835**	....
Total error	....	.0648	.1357
Coefficient of determination	R^2	....	....

* = Significant at the 5% level with 58 degrees of freedom.
** = Significant at the 1% level with 58 degrees of freedom.

SUMMARY AND CONCLUSIONS

The purpose of this study was to evaluate the factors which affect time and recovery of various fractions in the peeling and trimming operations during manufacture of canned and of frozen apple slices, and the interrelationships between the peeling and trimming operations.

No significant differences were found among four varieties of apples for yield of slices, screenings, peel and core waste, or trim waste for fruit of the same grade and size. Size showed in all instances a significant effect on yield of slices and on per cent screenings. There was a significant effect of size on peel and core waste between the smallest and the largest size class although there was not a significant difference between the small and medium or medium and large size classes when plant differences were taken into account. Size had no significant effect on total trim waste. Grade had a significant effect on yield of slices and on defect trim. No significant effect of grade on peel trim or on screenings was observed. Trimming time increased as size decreased and as total trim increased.

Variations in peels and cores and in total trim waste were the greatest cause for variations in yield of product. Because of the relationship of size of apples with both peel and core waste and total trim waste, size was a more important factor affecting yield than was grade. Variations in grade and in size have about equal effect on trimming time. One per cent increase in defect trim resulted in approximately 1.7 minutes increase in trimming time for 100 lbs. of apples of any size.

The estimating equations developed in this study from methods used in Experiment II may be used in plants which process apple slices for determining differential costs of peeling and trimming apples of different size and quality.

Acknowledgments

The authors wish to express their thanks to the following companies for their interest and cooperation: Knouse Foods Cooperative, Inc., Peach Glen, Pennsylvania; The C. H. Musselman Company, Biglerville, Pennsylvania; National Fruit Product Company, Inc., Shenandoah Valley Apple Cider and Vinegar Corp., and The Zeropack Company, of Winchester, Virginia. The cooperation of the following individuals and companies is also appreciated: Mr. J. H. Henley, Virginia State Apple and Peach Inspection Supervisor; Mr. Jack Shill, Chief Apple and Peach Inspector, Winchester Area, Virginia; Mr. D. K. Russell, apple grower of Clearbrook, Virginia; Mr. Roy E. Moser, Jr., of the Virginia Agricultural Extension Service; and Dr. Ralph G. Kline, of the Virginia Agricultural Experiment Station.

LITERATURE CITED

1. Anderson, R. L. The use of regression techniques with economic data. *Proc. Auburn Conference on Statistics Applied to Research in the Social Sciences, Plant Sciences, and Animal Sciences.* September 7–9, 1948.
2. Johnson, Joseph M., Lopez, Anthony, and Wood, Charles B. Determination of relative value of apples and evaluation of experimental processing apple grades. *Food Technol.*, 12, 554 (1958).
3. Lopez, Anthony, Wood, Charles B., and Johnson, Joseph M. Trimming time and yield factors in processing of applesauce. *Food Technol.*, 12, 57 (1958).
4. United States Department of Agriculture, Production and Marketing Administration. U. S. Standards for Apples for Processing. Effective September 2, 1946.

Factors Affecting Quality of Prepackaged Meat. V.[a, b]

Broad Comparisons of Variables and Quality Attributes[c]

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(Manuscript received March 20, 1956)

To assist in the analysis of the large volume of data of this project, extensive tabulations of results were made with the use of IBM cards. Unfortunately, the values of squares were not computed in making the tabulations; therefore, it was not possible to establish the degrees of significance applying to the comparisons. However, comparisons were made only when the amount of data presented was of the order of magnitude required, in the judgment of statisticians, to give results which would be statistically valid.[d]

These comparisons are considered to contribute materially to the value of the results in this investigation applying to fresh meat. Seventeen such tables were compiled but, to save space, only 7 of the more important tables are reproduced herein. Tables 1 to 7 are regarded as typical of the entire group.

The computations on which the tables are based, in certain instances, are valid only to the extent that they express the over-all character of the relationships between variables and attributes, which are indicated by the data; they do not reflect true values of data. For example, the values representing bacteria count are mean values of the logarithms of bacteria counts; the relative magnitudes of which differ rather widely from the relative magnitudes of the means of the actual counts. The sense of a difference in magnitude between values of an attribute representing two different values of a variable is the same in respect to the two values of the variable when the values of the attribute are means of the logarithms as when they are the means of the actual counts (anti-logarithms). In fact, a weak indication of significance arising intuitively from visual inspection of mean values of logarithms presents a strong probability of significance in the means of actual count values. Thus, for the purpose of making these comparisons, it makes no material difference whether directly determined numerical data are used or numerical values, which are functions of or even are merely symbolic of the data, are used.

Along with each value representing comparative data in the tables is given, in parentheses, the number of determinations which entered into the value. For instance, the first entry in column 3, Table 1 is 5.17(220) meaning that 220 determinations were averaged to produce the value 5.17.

The reliablity of a comparison depends, to a considerable extent, upon the degree to which both values used in the comparison represent approximately similar distributions of samples among given variables. To make a comparison, values in two columns of a table are used. The total number of the determinations involved in the data of a column is given in the first row of figures, opposite the designation "All Meat." The most reliable comparison is obtained when the ratio between the numbers of determinations in each row, i.e., for each variable classification, is identical to the ratio of the numbers of determinations shown in the first row. In other words, if the ratio in the first row is 2 : 1, the reliability of the comparison will be greatest if the ratio between the numbers of determinations in each subsequent row is 2 : 1. The greater the departure from this ratio in any row and the more blank rows there are, the lower is the reliability of the overall comparison coming from the two columns.

It is most desirable that the ratio referred to above be 1 : 1. However, a wide departure from the value of unity, in some cases, does not have as pronounced an effect upon the reliability of a comparison as it might casually be judged to have. For instance, the bacteria count values given in Table 1 for the days when the samples went into storage (0 days of storage) may be considered to accurately represent the facts even though comparatively few determinations are indicated because the technic used in the experimental work ensured general uniformity of bacteria count among the samples at this point in the procedure. For descriptions of the package types and procedures involved in the data discussed in Part V, and for definitions of terms, the reader is referred to Parts I to IV. In Part V, the term "fat meat" refers to meat containing from 35% to 50% of fat; the term "low-fat meat" refers to meat containing from 25% to 35% of fat.

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[a] A study of prepackaged fresh and cured meat extending through a period of five years, starting in 1949, was conducted by the Departments of Food Science and Animal Husbandry of Rutgers University. The investigation was divided into four divisions, classified as follows:

1. Physical and organoleptic studies.
2. Objective color studies.
3. Chemical studies related to organoleptic acceptance aside from color.
4. Microbiological studies.

This paper constitutes the final installment of the report on this investigation. Parts I, II, II, and IV were published in previous installments.

[b] A report of work conducted by contract with the Bureau of Animal Industry, U. S. Department of Agriculture, with funds provided under the Research and Marketing Act.

[c] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Departments of Food Science and Animal Husbandry, New Brunswick, N. J.

[d] Appreciation of the authors is expressed to the Animal Husbandry Division of the U. S. Bureau of Animal Industry, under the direction of T. C. Byerly, for the machine work involved in this analysis and to Simon Lopata of the Department of Economics, Rutgers University, for directing the computations that resulted in the comparisons tabulated herein.

The reader may make his own estimates of the degrees of significance of the relationships indicated in Tables 1 to 7. Certain indications as to how the relationships appear to the authors are given in the comments that follow. These comments refer to comparisons indicated by tables not presented herein as well as those indicated by Tables 1 to 7. The comments are based entirely upon the data after passing through the card analysis and machine computations, without reference to conclusions presented in the earlier sections of this report. Any discrepancies between Part V and Parts I, II, III, and IV constitute examples of differences in indications that may result from different analytical approaches.

BACTERIA COUNT

Bacteria count of *beef* increased continuously during a storage period of 4 weeks at 32°–44° F. whereas that in *pork* and *lamb*, after increasing for 3 weeks, showed a tendency to remain constant during the fourth week, due to a tendency for the number of bacteria in *fat samples of pork and lamb* to decrease during this period. (See Table 1).

Bacteria count in packaged *cuts of meat* increased at a somewhat lower rate than that of *ground meat* during the first week of storage but at a higher rate than that of ground meat during the second and third weeks. During the fourth week, the bacteria count of *cuts* showed a tendency to decrease while that of *ground meat* continued to increase. The maximum count of *cut meat* was generally less than that of *ground meat*.

Fat meat, both cut and ground, showed a much higher rate of growth during the first week of storage than *lean meat* but a somewhat lower rate after the first week, and the peak count of *fat meat* was somewhat higher than that of *lean*.

TABLE 1

Total bacteria count

	Log of bacteria count				
	0 days	6–7 days	13–14 days	20–21 days	28–32 days
All meat	2.92(32)	5.17(220)	5.93(225)	6.96(206)	6.80(129)
All beef	3.76 (8)	5.64(79)	6.12(83)	7.77(77)	8.12(37)
All pork	2.34(18)	4.49(88)	5.61(88)	6.05(75)	6.07(77)
All lamb	3.60(6)	5.62(53)	6.52(54)	7.08(54)	7.21(15)
All lean	3.01(15)	4.87(105)	6.25(102)	6.84(103)	6.70(73)
Lean beef	3.41(4)	5.04(39)	6.14(36)	7.58(38)	7.96(18)
Lean pork	2.59(8)	4.42(39)	5.77(39)	6.20(38)	6.15(40)
Lean lamb	3.60(3)	6.74(27)	6.44(27)	6.95(27)	6.62(15)
All fat[1]	2.90(17	5.45(115)	6.35(113)	7.08(103)	6.74(75)
Fat beef	4.14(4)	6.21(40)	7.31(37)	7.97(39)	8.29(19)
Fat pork	2.09(10)	4.55(49)	5.70(49)	6.08(37)	5.92(38)
Fat lamb	3.60(3)	6.20(18)	6.54(27)	7.20(27)	6.82(18)
Ground meat	3.23(2)	5.66(108)	6.60(109)	7.26(107)	7.27(88)
Ground beef	3.23(2)	5.62(55)	6.92(55)	7.98(53)	8.12(37)
Ground pork	.....	5.93(18)	6.29(18)	6.30(18)	6.50(18)
Ground lamb	.....	5.56(35)	6.26(36)	6.80(36)	6.74(33)
Cut meat	2.90(30)	4.70(112)	6.00(106)	6.65(99)	5.89(60)
Cut beef	3.95(6)	5.64(24)	7.08(18)	7.30(24)	.....
Cut pork	2.32(18)	4.11(70)	5.45(70)	5.98(57)	5.89(60)
Cut lamb	3.60(6)	5.75(18)	7.07(18)	7.86(18)	.....
Ground lean	3.32(1)	5.20(54)	6.35(54)	7.08(53)	7.17(42)
Cut lean	2.99(14)	4.50(51)	6.11(48)	6.59(50)	6.04(31)
Ground fat	3.15(1)	6.10(54)	6.96(55)	7.44(54)	7.36(46)
Cut fat	2.82(16)	4.88(61)	5.88(58)	6.70(49)	5.74(29)

[1] "Fat" meat contained 35–50% fat.

MEASURED VACUUM AFTER STORAGE[e]

There was a higher rate of reduction of vacuum after the first week of storage in *ground* than in *cut* samples.

In *beef* and *lamb*, but not in *pork*, there was a slightly higher rate of reduction in vacuum after the first week of storage in *fat meat* than in *lean meat*.

In order of increasing rate of reduction of vacuum after the first week of storage, the 3 species of meat ranked as follows: *pork, beef, lamb*. The good showing of pork may be attributed to the fact that cuts of pork, both lean and fat showed practically no reduction of vacuuum after the first week of storage.

A loss of 2 inches of vacuum during the second, third and fourth weeks constituted a loss of major proportions.

The loss of vacuum was greatest in the *smallest can* and least in the *largest can*.

During the total storage periods, the mean loss of vacuum in samples held at 42°–44° F. was approximately 0.5 in. greater than that of samples held at 32°–34° F.

During the total storage periods, the mean loss of vacuum in samples held for 20 hours at room temperature before they were put into storage at 32–34° F. was approximately 1.2 in. greater than that of samples held at 32–34° F. from the time of packaging.

Note: The last 3 comparisons given above constitute substantial evidence that a considerable quantity of gas was liberated from the meat in the package and that the amount of gas liberated depended upon the storage temperature. A reasonable conclusion appears to be that this gas was liberated by bacteria. Somewhat inadequate data, however, on samples that were inoculated with *Achromobacter sp.* did not indicate a greater loss of vacuum in these samples than in samples which were not inoculated. If reliance can be placed in these data, it seems that *Achromobacter* did not contribute to the loss of vacuum.

COLOR[f]

Data from the subjective evaluation of color of prepackaged samples shows a pattern which depended, in a major sense, upon the ratio of cans to film packages in the groups represented by the scores. If a group contained a large percentage of cans, the mean color rating for the group tended to improve during the second and third weeks of storage. If the group contained a small percentage of cans, the mean color rating for the group tended to decrease during the second and third weeks of storage. After the first 2 to 5 days, color changes that occurred in cans tended to counterbalance changes that occurred in the film packages.

Lamb, after deteriorating in color rapidly during the first 4 or 5 days of storage, recovered its red color during the second and third weeks of storage better than *beef* or *pork*.

Pork, after deteriorating in color rapidly during the first 4 or 5 days of storage, recovered its red color for a short time more rapidly than *beef* or *lamb*, then lost red color again.

Beef showed less change in color after the first week than *pork* or *lamb*.

Based upon intensity of red color throughout the storage periods, 9 package types seem to fall into the following order, from best to poorest:

1. 307 x 113 can.
2. MSAT80 cellophane, wrapped, coated side out.
3. Cellophane-pliofilm laminate.
4. 307 x 306 can.
5. Cellophane-polyethylene laminate.
6. Polyethylene.
7. MSAT80 cellophane, coated side inside.
8. MSAT80 cellophane, coated side outside.
9. Cellulose acetate—pliofilm laminate.

Wrapped MSAT80 cellophane and cellophane-polyethylene laminate packages were represented by very low numbers of samples, comparatively speaking; therefore, their ratings should be regarded with question.

Based upon the intensity of red color throughout the storage periods, samples stored at from 41 to 46° F. were somewhat better than samples stored at from 32 to 34° F.

Observations on a very small number of samples stored below zero F. indicated the color of these samples to be inferior to that of samples stored at from 32 to 34° F.

[e] Package types 1, 2, and 13 (cans).

[f] Subjective evaluation of outside surface of raw meat.

FLAVOR

When all meat in all package types is considered as a sample, deterioration of flavor, as judged by a panel using a numerical rating system, progressed continuously during storage for 3 weeks. (See Table 2). The rate of deterioration was higher during the first week than during the second week and higher during the second week than during the third week. Scant data indicate that deterioration of flavor during the fourth week was scarcely perceptible.

There was more rapid flavor deterioration throughout the period of storage (1) in *fat meat* than in *lean meat*, (2) in *ground meat* than in *cut meat*, and (3) in *lamb* than in *beef*. The inferiority of *ground meat* to *cut meat* was especially pronounced in samples stored above 40° F. and in samples treated with ascorbic acid.

Pork flavor deteriorated less rapidly than flavor of either *beef* or *lamb* during the first week of storage but more rapidly than the flavor of either of the other species of meat during the second and third weeks.

Flavor held up best in *low fat* samples, next best in *lean* samples, and poorest in *fat* samples.

Flavor was somewhat better in samples packaged in cellophane-pliofilm laminate (package type 15) than in those packaged in the 307 x 113 can (package type 2).

Except for *lean pork* and *lean lamb*, flavor in samples stored above 40° F. was as good as or better than that of samples stored between 32° and 40° F.

Flavor was somewhat better in samples stored under refrigeration from the time of packaging than in samples held for 20 hours at room temperature before refrigerating.

No effect of light on flavor was indicated.

Flavor was somewhat better in samples stored at normal humidity than in samples stored at 80–82% relative humidity.

Inoculation with *Achromobacter* appeared to have no effect on the retention of flavor in storage.

In *ground lamb* treated with ascorbic acid, flavor deteriorated more rapidly than in untreated samples; in *cut beef*, there was very little difference in flavor retention between treated and untreated samples; however, *fat beef* treated with ascorbic acid showed some tendency to retain good flavor better than untreated samples. *Pork*, *cut samples of lamb*, and *ground samples of beef* were not included in the ascorbic acid tests.

COOKED ODOR

When *all meat* in all package types is considered as a sample, deterioration of the odor of the meat after cooking, as judged by a panel using a numerical rating system, progressed continuously during storage as raw meat for 3 weeks. The rate of deterioration was higher during the first week than during subsequent weeks. Scant data indicate that there was further deterioration of cooked odor during the fourth week but at a lower rate than during the preceding period.

There was more rapid odor deterioration throughout the period of storage (1) in *fat meat* than in *lean meat*, (2) in *ground meat* than in *cut meat*, and (3) in *lamb* than in *beef*. The inferiority of *ground meat* to *cut meat* was especially pro-

TABLE 2

Flavor, in relation to variables in preparation, packaging, and storage of meat, as indicated by numerical system of evaluation (Perfect score = 9)

Levels of consideration	Days in storage			Storage temperature				Pattern of temperature	
	6–8	13–15	20–22	32°–34°	35°–37°	38°–40°	41°–50°	1 temp.	20 hours room temp.
All meat	6.76(335)	5.48(181)	5.00(112)	6.18(160)	6.13(307)	6.13(447)	6.21(450)	6.39(1615)	5.17(29)
All lean meat	6.98(163)	5.69(107)	5.26(70)	6.37(43)	5.91(127)	6.43(300)	6.29(235)	6.49(832)	6.07(13)
All 35-50% fat meat	6.18(103)	5.18(74)	4.57(42)	5.28(67)	6.18(170)	4.71(97)	5.52(135)	5.87(548)	4.43(16)
All 25-35% fat meat	7.10(69)	....	....	7.22(50)	8.10(10)	X X	7.19(80)	7.30(235)	....
All ground lean	6.80(76)	5.34(58)	4.82(33)	6.37(43)	5.91(127)	6.18(105)	5.03(58)	6.19(385)	6.07(13)
All cut lean	7.14(87)	6.10(49)	5.65(37)	....	....	6.57(195)	6.70(177)	6.74(447)	....
All ground 35-50% fat	5.93(73)	4.70(60)	4.11(28)	5.28(67)	5.88(98)	4.71(97)	4.62(70)	5.51(377)	4.43(16)
All cut 35-50% fat	6.80(30)	7.20(14)	5.50(14)	....	6.50(73)	....	6.50(65)	6.67(171)	....
All beef	6.82(103)	6.11(82)	5.45(73)	5.60(68)	5.94(129)	6.38(197)	6.90(78)	6.38(549)	7.00(2)
All pork	7.13(100)	4.92(38)	3.50(14)	6.66(35)	6.95(59)	6.40(139)	6.21(191)	6.62(535)	....
All lamb	6.44(132)	4.98(61)	4.52(25)	6.58(57)	5.93(119)	5.35(111)	6.49(181)	6.17(531)	5.03(27)
All lean beef	7.12(75)	6.00(57)	5.63(49)	6.25(28)	5.64(36)	6.47(192)	6.90(78)	6.58(387)	....
All lean pork	7.20(45)	5.42(19)	3.88(8)	5.00(1)	7.17(23)	6.45(51)	6.14(117)	6.63(248)	....
All lean lamb	6.51(43)	5.29(31)	4.69(13)	6.71(14)	5.63(68)	6.28(57)	5.47(40)	6.14(197)	6.07(13)
All 35-50% fat beef	6.00(28)	6.36(25)	5.08(24)	5.15(40)	6.05(93)	3.00(5)	....	5.93(162)	7.00(2)
All 35-50% fat pork	7.13(32)	4.42(19)	3.00(6)	4.75(4)	6.81(36)	5.42(38)	6.32(74)	6.40(192)	....
All 35-50% fat lamb	5.60(43)	4.67(30)	4.33(12)	5.61(23)	5.90(41)	4.37(54)	4.56(61)	5.30(194)	4.07(14)
All ground beef	6.68(31)	5.39(23)	5.22(23)	5.60(68)	5.12(57)	4.12(17)	....	5.72(169)	7.00(2)
All ground pork	6.93(41)	4.82(34)	3.15(13)	6.55(20)	6.95(59)	6.03(97)	4.37(27)	6.34(245)	....
All ground lamb	6.29(109)	4.98(61)	4.52(35)	6.34(47)	5.83(114)	5.35(111)	6.28(141)	5.98(461)	5.03(27)

Levels of consideration	Storage light		Storage room humidity		Bacterial inoculation		Antioxidant		Type of package	
	Light	Darkness	Normal	80–82%	None	Achromobacter	Non-treated	Ascorbic acid added	307 x 113 can	Cellophane-pliofilm laminate
All meat	6.88(591)	6.45(993)	6.95(613)	5.98(945)	6.38(1611)	X X	6.46(1419)	5.83(224)	6.60(233)	6.78(711)
All lean meat	6.64(237)	6.42(608)	6.81(226)	6.34(546)	6.49(821)	....	6.55(708)	6.10(136)	6.70(127)	6.80(431)
All 35-50% fat meat	6.59(119)	6.50(385)	6.64(152)	5.49(399)	5.83(555)	....	5.91(476)	5.42(88)	6.14(76)	6.54(221)
All 25-35% fat meat	7.28(235)	....	7.28(235)	....	7.28(235)	....	7.28(235)	....	7.42(45)	7.47(59)
All ground lean	....	6.19(398)	6.50(2)	6.18(391)	6.19(398)	....	6.31(359)	5.13(31)	6.24(17)	6.90(124)
All cut lean	6.64(237)	6.86(210)	6.81(234)	X X	6.77(425)	....	6.80(349)	6.59(96)	6.77(110)	6.76(307)
All ground 35-50% fat	X X	6.45(333)	....	7.13(386)	5.46(384)	5.67(9)	6.30(353)	4.25(31)	4.69(16)	6.39(120)
All cut 35-50% fat	6.59(119)	X X	6.64(152)	X X	6.67(171)	6.62(81)	6.72(123)	6.52(48)	6.53(60)	6.72(101)
All beef	6.66(280)	7.84(211)	6.69(261)	5.98(220)	6.39(527)	....	6.32(406)	6.57(144)	6.71(115)	6.73(279)
All pork	6.80(171)	6.53(364)	6.94(212)	6.38(317)	6.63(526)	....	6.62(535)	....	6.73(71)	6.82(258)
All lamb	7.44(140)	5.68(418)	X X	5.67(408)	6.12(558)	....	6.39(478)	4.51(80)	6.50(62)	6.78(174)
All lean beef	6.67(196)	6.48(191)	6.72(177)	6.42(142)	6.60(363)	....	6.57(290)	6.59(96)	6.77(79)	6.75(211)
All lean pork	6.49(41)	6.65(207)	7.12(49)	6.50(199)	6.63(248)	....	6.63(248)	....	6.75(32)	6.85(156)
All lean lamb	....	6.13(210)	....	6.12(205)	6.13(210)	....	6.42(170)	4.93(40)	6.25(16)	6.83(64)
All 35-50% fat beef	6.62(84)	20.90(20)	6.62(84)	5.18(78)	5.94(164)	....	5.70(116)	6.52(48)	6.58(36)	6.66(68)
All 35-50% fat pork	6.51(35)	6.38(157)	6.68(68)	6.16(118)	6.44(183)	6.52(90)	6.40(192)	....	6.46(24)	6.76(92)
All 35-50% fat lamb	....	5.22(208)	....	5.21(203)	5.22(208)	....	5.48(168)	4.10(40)	4.69(16)	6.08(61)
All ground beef	....	8.83(111)	X X	5.71(168)	5.73(171)	....	5.70(172)	....	X X	6.95(43)
All ground pork	X X	6.22(202)	6.86(44)	6.22(201)	6.36(236)	....	6.33(245)	....	X X	6.79(81)
All ground lamb	X X	5.68(418)	X X	5.67(408)	5.93(488)	X X	6.21(408)	4.51(80)	4.67(47)	6.68(149)

Notes: Numbers in parentheses show numbers of samples observed; .... = No observations; X = Insufficient observations.

nounced in samples stored above 40° F. and in samples treated with ascorbic acid.

Pork deteriorated in respect to cooked odor less rapidly than either *beef* or *lamb* during the first week of storage but more rapidly than either of the other species of meat during the second and third weeks.

Odor held up best in *low fat* samples, next best in *lean* samples, and poorest in *fat* samples.

There was no apparent difference in odor of the cooked meat, depending upon whether the meat was packaged in cans (package No. 2) or in cellophane-pliofilm laminate pouches (package No. 15).

Except for *lamb*, lean and fat, cooked odor of samples stored above 40° F. was as good as or better than that of samples stored between 32° and 40° F.

The data gave no clear cut indication as to whether or not there was a difference in cooked odor between samples stored under refrigeration from the time of packaging and samples held for 20 hours at room temperature before refrigerating.

The rating for odor of the cooked product was higher for samples that were stored in a lighted space than for samples that were stored in the dark.

The rating for odor of the cooked product was higher for samples stored at normal humidity than in samples stored at 80–100% relative humidity.

In *ground lamb* treated with ascorbic acid, odor deteriorated more rapidly than in untreated samples; in *cut beef*, particularly *fat beef*, a tendency was indicated for good cooked odor to be retained better in samples treated with ascorbic acid than in untreated samples. These tests did not include *pork*, *cut samples of lamb*, or *ground samples of beef*.

TOTAL ORGANOLEPTIC QUALITY MINUS COLOR

When *all meat* in all package types is considered as a sample, deterioration of total organoleptic quality, excluding color, progressed continuously for the first 2 weeks of storage but during the next 2 weeks there was practically no change in the rating for this factor. (See Table 3).

The above statement applied to both *lean and fat meat*, although deterioration during the first 2 weeks of storage was greater in *fat meat* than in *lean meat*. *Ground fat meat* deteriorated substantially more than *cut fat meat*, whereas there was practically no difference in this respect between *ground* and *cut lean meat*, neither of which lost quality to the extent to which it was lost by *ground fat meat*.

In respect to time of storage, each of the 3 species of meat had a unique pattern of loss of total organoleptic quality with color excepted. *Beef*, both lean and fat, deteriorated continuously throughout 4 weeks of storage; *pork*, both lean and fat, lost quality for 3 weeks, then regained quality during the fourth week; *lamb*, both lean and fat, lost quality for 2 weeks, then regained quality during the third and fourth weeks.

Cut samples deteriorated in quality more slowly than *ground* samples. This distinction is more pronounced in *fat samples* than in *lean*.

Variation in storage temperature between 32° and 50° F. had almost no effect upon the rate of loss of quality in *lean* or in *low-fat* meat. In *fat* meat, however, quality deteriorated more rapidly in storage at temperatures above 38° than at temperatures below 38° F.

Low-fat meat was more stable in quality retention than any other class of meat.

The rating for total organoleptic quality, less color, was higher in samples stored under refrigeration from the time of packaging than in samples held for 20 hours at room temperature before refrigerating.

The rating for total organoleptic quality, less color, was higher in samples stored in the light than in samples stored in absence of light. This difference appeared to be due to *low-fat* samples, which showed a marked superiority in light storage over the quality of lean and fat samples stored in absence of light. No *low-fat* samples were stored in absence of light. *Fat beef* samples in light storage also showed superiority over similar samples stored in absence of light but there was no apparent effect of this factor on *fat pork* samples.

Organoleptic quality, excluding color, was slightly better in samples stored at normal humidity than in samples stored at 80–82% relative humidity.

Ground lamb treated with ascorbic acid deteriorated more rapidly than untreated samples. In *cut beef*, there was little difference in quality retention between treated and untreated samples, although *fat beef* treated with ascorbic acid showed a tendency to retain good quality better than untreated samples. *Pork*, *cut samples of lamb* and *ground samples of beef* were not included in the ascorbic acid tests.

Total organoleptic quality, excluding color, was slightly better in samples packaged in cellophane-pliofilm laminate (package type 15) than in those packaged in cans (package types 2 and 13).

Inadequate data indicated that samples packaged in cellophane-polyethylene laminate (package type No. 16) and in MSAT80 wrapped cellophane (package type 6w) were on a par with those in package type 15, and that those in MSAT80 cellophane pouches, coated side outside (package type 6d) and in cellulose acetate-pliofilm laminate (package type 17) were inferior to those in package type 15. Only *low-fat* samples were packaged in wrapped MSAT80 cellophane (package type 6w).

TOTAL ORGANOLEPTIC QUALITY, INCLUDING COLOR

When *all lean meat* in all package types is considered as a sample, deterioration in total organoleptic quality progressed continuously for the first 2 weeks of storage but during the next 2 weeks there was practically no change in the rating for this factor. *Fat meat* deteriorated continuously throughout 4 weeks of storage. In the cases of both *lean* and *fat meat*, *ground meat* deteriorated faster than *cut meat*. (See Table 4).

In respect to time of storage, each of the 3 species of meat had a unique pattern of loss of total organoleptic quality. *Beef*, both lean and fat, suffered a practically continuous loss of quality throughout 4 weeks of storage; *pork*, both lean and fat, and *fat lamb* lost quality for 3 weeks, then regained quality during the fourth week; *lean lamb* lost quality for 2 weeks, then regained quality during the third and fourth weeks.

There seems to be no consistent pattern for the effect of variation in storage temperature between 32° and 50° F. upon total organoleptic quality except in *cut lean beef*, which had better quality when stored at temperatures above 38° F. than when stored at lower temperatures.

There seems to be no consistent pattern indicated in a comparison of the effect of light storage with the effect of dark storage upon total organoleptic quality of *all classes* of fresh meat.

Total organoleptic quality was slightly better in samples stored at normal humidity than in samples stored at 80–82% relative humidity.

Ground lamb treated with ascorbic acid deteriorated more rapidly than untreated samples; in *cut beef*, both fat and lean, there was slightly better retention of quality in treated samples than in non-treated samples. Comparisons of ascorbic acid treated versus non-treated samples were not made for *pork*, *cut lamb*, or *ground beef*.

In rating for total organoleptic quality, including color, there was no appreciable difference between samples packaged in cellophane-pliofilm laminate (package type 15) and those packaged in the smallest cans (package type 2). Samples in the larger can (307–306) were inferior to those in the smallest can, 307–113.

Inadequate data indicated as follows:

a. Wrapped MSAT80 cellophane packages (type 6w), which were filled with *low-fat* samples only, gave a lower quality rating in this type of sample than package types 2 and 15.

TABLE 3

Total organoleptic quality, minus color, in relation to variables in preparation, packaging, and storage of meat (Perfect score = 80)

Levels of consideration	Days in storage				Storage temperature				Pattern of temperature	
	6–8	13–15	20–22	23–28	32°–34°	35°–37°	38°–40°	41°–50°	1-temp.	20 hours room temp.
All meat	61.9(314)	54.0(158)	53.4(98)	54.00(131)	59.3(155)	59.0(301)	59.0(430)	57.1(408)	60.1(1542)	55.7(22)
All lean meat	62.2(152)	55.0(91)	54.4(62)	55.50(66)	59.8(38)	58.5(121)	59.5(291)	59.1(213)	60.0(788)	59.9(10)
All 35-50% fat meat	60.1(97)	52.3(67)	51.7(36)	52.80(65)	54.9(67)	58.8(170)	54.0(89)	48.0(116)	58.0(520)	52.0(12)
All 25-35% fat meat	63.8(65)	....	....	....	64.8(50)	69.3(10)	65.0(50)	65.0(79)	65.3(234)	....
All ground lean	62.6(66)	52.5(47)	54.6(25)	54.2(35)	59.8(38)	58.5(121)	59.0(100)	52.0(36)	59.2(345)	59.9(10)
All cut lean	61.9(86)	58.0(44)	54.2(37)	57.0(31)	....	....	59.8(191)	60.1(177)	60.6(443)	....
All ground 35-50% fat	58.7(67)	49.2(53)	49.1(22)	50.5(34)	54.9(67)	57.7(98)	54.0(89)	53.0(51)	56.7(349)	52.0(12)
All cut 35-50% fat	63.3(30)	64.2(14)	55.6(14)	55.3(31)	....	....	....	59.3(65)	60.6(171)	....
All beef	60.4(99)	57.7(65)	54.8(71)	48.0(29)	56.0(63)	57.2(123)	58.6(193)	60.0(78)	58.7(532)	63.0(2)
All pork	65.0(96)	54.7(29)	46.5(14)	55.5(82)	61.9(35)	64.7(59)	61.8(139)	64.0(191)	61.9(537)	....
All lamb	56.3(119)	49.8(64)	53.0(13)	57.2(20)	61.3(57)	58.0(119)	56.0(98)	59.5(139)	59.6(473)	54.9(20)
All lean beef	61.4(71)	56.8(45)	54.9(47)	49.9(15)	58.9(23)	56.0(30)	58.9(188)	60.0(78)	59.3(370)	....
All lean pork	64.3(45)	54.8(15)	49.5(8)	56.4(41)	....	63.8(23)	61.6(57)	59.3(117)	61.6(250)	....
All lean lamb	61.2(36)	52.8(31)	56.6(7)	60.0(10)	61.7(14)	57.8(68)	59.7(52)	53.6(18)	59.1(168)	59.9(10)
All 35-50% fat beef	58.0(28)	59.8(20)	54.7(24)	46.1(14)	54.3(40)	57.6(93)	46.0(5)	....	57.5(162)	63.0(2)
All 35-50% fat pork	66.7(32)	54.5(14)	42.5(6)	54.6(41)	55.0(4)	65.3(36)	57.8(38)	59.1(74)	61.2(192)	....
All 35-50% fat lamb	56.1(37)	46.9(33)	48.8(6)	54.5(10)	55.9(23)	55.8(41)	51.8(46)	52.0(42)	54.8(166)	49.9(10)
All ground beef	61.5(28)	49.2(11)	55.7(21)	48.0(29)	56.0(63)	53.0(51)	49.9(17)	....	56.3(158)	63.0(2)
All ground pork	64.5(41)	53.8(25)	45.2(13)	53.9(20)	61.9(20)	64.9(54)	60.6(97)	52.7(27)	61.7(245)	....
All ground lamb	60.1(96)	49.8(64)	53.0(13)	57.2(20)	60.1(47)	57.5(114)	56.0(98)	57.7(100)	58.7(404)	54.9(20)

Levels of consideration	Storage light		Storage room humidity		Bacterial inoculation		Antioxidant	
	Light	Darkness	Normal	80–82%	None	Achromobacter	Non-treated	Ascorbic acid added
All meat	62.1(590	58.9(974)	62.3(612)	58.5(868)	60.1(1531)	X	60.7(1330)	57.3(215)
All lean meat	59.7(237)	60.1(561)	60.5(226)	59.8(501)	60.1(774)	X	60.6(656)	57.7(132)
All 35-50% fat meat	60.3(119)	57.1(413)	60.3(152)	56.7(367)	57.8(523)	X	58.3(440)	56.7(83)
All 25-35% fat meat	65.1(234)	....	65.3(234)	....	65.3(234)	X	65.3(234)	....
All ground lean	....	59.2(355)	58.5(2)	59.2(348)	59.2(355)	X	60.1(311)	54.0(35)
All cut lean	59.7(237)	61.7(206)	60.6(224)	61.2(153)	60.8(419)	X	61.1(345)	59.0(97)
All ground 35-50% fat	....	56.6(361)	....	56.5(354)	56.5(352)	X	57.4(317)	51.7(35)
All cut 35-50% fat	60.3(119)	61.0(52)	60.3(152)	60.7(13)	60.6(171)	X	60.8(123)	60.1(48)
All beef	59.8(280)	57.7(254)	59.8(261)	57.2(205)	58.8(510)	X	58.5(388)	59.4(145)
All pork	62.7(171)	61.6(366)	62.9(212)	61.2(319)	62.0(528)	X	62.0(537)	....
All lamb	66.0(139)	56.8(354)	56.8(344)	56.8(344)	59.4(493)	X	61.0(405)	52.9(70)
All lean beef	59.5(196)	59.1(174)	59.6(177)	58.8(127)	59.4(346)	X	59.4(272)	59.0(97)
All lean pork	60.7(41)	61.8(209)	64.0(48)	61.1(201)	61.6(250)	X	61.6(250)	....
All lean lamb	....	59.1(178)	....	59.1(173)	59.1(178)	X	61.1(134)	54.0(35)
All 35-50% fat beef	60.3(84)	54.6(80)	60.3(84)	54.4(78)	57.2(164)	X	56.4(116)	60.1(48)
All 35-50% fat pork	60.8(35)	61.3(157)	60.3(68)	61.4(118)	61.2(183)	60.67(9)	61.2(192)	....
All 35-50% fat lamb	....	54.5(176)	....	54.4(171)	54.5(176)	X	55.7(132)	51.7(35)
All ground beef	....	56.4(160)	55.0(1)	56.4(157)	56.4(160)	X	56.4(160)	....
All ground pork	65.3(43)	60.9(202)	65.3(44)	60.9(201)	61.7(236)	X	61.7(245)	....
All ground lamb	66.8(70)	56.8(354)	....	56.8(344)	58.5(424)	X	60.2(336)	52.9(70)

Levels of consideration	Type of package						
	307 x 113 can	307 x 306 can	MSAT80 cellophane-coated side outside	Wrapped MSAT80 cellophane-coated side outside	Cellophane-pliofilm laminate	Cellophane-polyethylene laminate	Cellulose acetate-pliofilm laminate
All meat	60.9(247)	57.8(265)	58.8(65)	64.8(41)	61.6(682)	62.0(24)	56.7(32)
All lean meat	60.4(126)	59.5(131)	49.3(11)	....	61.4(413)	62.2(12)	57.0(16)
All 35-50% fat meat	58.2(76)	56.0(134)	50.5(14)	....	60.8(211)	62.0(12)	56.3(16)
All 25-35% fat meat	60.0(45)	....	64.3(40)	64.8(41)	65.8(58)	....	....
All ground lean	59.2(17)	59.5(131)	49.3(11)	....	62.7(109)	62.2(12)	57.0(16)
All cut lean	60.6(109)	....	....	....	60.9(304)	....	....
All ground 35-50% fat	67.6(15)	56.0(134)	50.5(14)	....	61.0(110)	62.0(12)	56.3(16)
All cut 35-50% fat	59.4(60)	....	....	....	60.6(101)	....	....
All beef	60.0(114)	54.1(64)	....	....	60.3(270)	59.1(12)	53.6(20)
All pork	61.3(71)	59.7(87)	56.3(25)	62.1(10)	62.5(260)	65.0(12)	61.9(12)
All lamb	61.9(62)	58.2(114)	60.3(40)	65.6(31)	62.3(152)	....	....
All lean beef	60.1(78)	56.7(32)	....	....	60.0(202)	60.7(6)	54.6(10)
All lean pork	61.7(32)	59.2(42)	48.2(6)	....	62.7(158)	63.7(6)	61.3(6)
All lean lamb	59.5(16)	61.2(57)	50.8(5)	....	62.3(53)	....	....
All 35-60% fat beef	59.9(36)	51.4(32)	....	....	61.0(68)	57.7(6)	52.6(10)
All 35-50% fat pork	58.6(24)	60.2(45)	54.2(9)	....	61.9(92)	66.3(6)	62.5(6)
All 35-50% fat lamb	53.9(16)	55.3(57)	43.8(5)	....	58.7(51)	....	....
All ground beef	....	54.1(64)	....	....	62.8(39)	59.1(12)	53.6(20)
All ground pork	....	59.7(87)	53.8(20)	64.4(5)	63.4(81)	65.0(12)	61.9(12)
All ground lamb	60.2(47)	58.2(114)	57.7(25)	65.9(16)	61.9(128)	....	....

Notes: Numbers in parentheses show numbers of samples observed; .... = No observations; X = Insufficient observations.

b. Samples in cellophane-polyethylene laminate were on a par with those in package types 2 and 15.

c. Samples in cellulose acetate-pliofilm laminate had a lower rating than those in package types 2 and 15.

d. Samples in MSAT80 cellophane pouches, coated side outside, had a lower rating than those in cellulose acetate-pliofilm laminate.

Note: Low-fat samples were not used in the early part of the project; they were introduced after the project was more than half finished. At the same time, the use of fat samples (more than 35% fat) was discontinued. There is no direct indication that the standards of the panel shifted either up or down in the course of the project but in case the panel should have involuntarily raised the numerical level of its rating for

TABLE 4

Total organoleptic quality, including color, in relation to variables in preparation, packaging, and storage of meat (Perfect score = 100)

Levels of consideration	Days in storage				Storage temperature			
	6–8	13–15	20–22	23–28	32°–34°	35°–37°	38°–40°	41°–50°
All meat	75.5(299)	67.6(143)	66.1(97)	65.9(112)	72.1(156)	72.5(277)	72.5(404)	73.9(391)
All lean meat	75.2(146)	67.2(87)	67.0(62)	67.5(64)	70.6(42)	71.0(103)	71.8(293)	73.5(207)
All 35-50% fat meat	74.0(89)	68.2(56)	64.5(35)	63.7(48)	68.0(66)	72.9(166)	68.5(61)	70.3(106)
All 25-35% fat meat	78.4(64)	....	....	....	78.9(48)	X X	X X	79.7(78)
All ground lean	74.9(60)	66.0(43)	66.2(21)	66.0(33)	70.6(42)	71.0(103)	72.9(97)	65.8(30)
All cut lean	75.5(86)	68.4(44)	66.7(36)	68.8(31)	....	....	71.2(196)	74.8(177)
All ground 35-50% fat	71.4(59)	64.9(42)	61.5(21)	63.2(32)	68.0(66)	71.6(94)	68.5(61)	65.3(42)
All cut 35-50% fat	79.1(30)	78.0(14)	69.0(14)	64.2(16)	....	X X	....	73.6(64)
All beef	72.5(99)	68.3(67)	66.7(70)	57.5(27)	67.3(68)	69.7(129)	69.5(198)	75.5(78)
All pork	79.5(94)	70.9(26)	60.3(14)	67.7(65)	76.7(33)	80.1(59)	77.2(133)	72.1(187)
All lamb	74.8(106)	65.0(50)	66.4(13)	71.1(20)	75.1(55)	71.4(89)	71.9(33)	74.5(126)
All lean beef	72.4(62)	66.3(47)	67.1(47)	64.9(14)	68.9(28)	64.8(36)	69.8(193)	75.5(78)
All lean pork	78.3(44)	70.8(15)	63.5(8)	69.3(40)	X X	79.7(23)	77.0(51)	72.5(117)
All lean lamb	75.7(30)	66.8(25)	70.4(7)	73.9(10)	74.1(13)	71.8(44)	73.9(49)	69.3(12)
All 35-50% fat beef	70.8(27)	73.1(20)	67.5(23)	57.1(13)	66.2(40)	71.6(93)	58.6(5)	....
All 35-50% fat pork	80.9(31)	70.9(11)	56.0(6)	65.2(25)	X X	80.8(36)	70.7(32)	73.0(70)
All 35-50% fat lamb	69.8(31)	63.1(25)	61.7(6)	68.3(10)	70.9(22)	68.7(37)	67.8(24)	65.0(36)
All ground beef	69.2(28)	59.8(13)	67.4(31)	57.5(27)	67.3(68)	63.4(57)	60.5(17)	....
All ground pork	78.5(39)	70.0(22)	59.0(13)	69.0(18)	78.3(18)	80.1(59)	75.4(91)	64.4(24)
All ground lamb	74.4(83)	65.0(50)	66.4(13)	71.1(20)	73.9(45)	70.8(84)	71.9(73)	72.8(88)

Levels of consideration	Pattern of temperature		Storage light		Storage room humidity		Antioxidant	
	1-temp.	20 hours room temp.	Light	Darkness	Normal	80–82%	Non-treated	.05%–.50% ascorbic acid added
All meat	71.7(1444)	69.7(20)	73.5(583)	72.1(881)	76.7(605)	71.6(775)	74.1(1246)	71.8(187)
All lean meat	73.0(752)	71.6(9)	73.0(236)	73.0(525)	74.3(225)	72.5(465)	73.4(625)	71.8(111)
All 35-50% fat meat	71.8(464)	68.2(11)	78.0(119)	70.8(356)	74.4(152)	71.6(310)	71.6(393)	71.8(76)
All 25-35% fat meat	67.5(228)	....	80.5(228)	....	80.6(228)	....	80.6(228)	....
All ground lean	70.0(305)	68.2(9)	....	72.1(314)	78.5(2)	72.1(307)	73.4(625)	69.3(27)
All cut lean	73.6(447)	....	73.0(236)	74.3(211)	74.2(223)	73.4(158)	74.2(338)	72.5(84)
All ground 35-50% fat	70.1(293)	68.2(11)	....	70.0(304)	....	70.0(297)	70.3(276)	67.2(28)
All cut 35-50% fat	74.7(171)	....	78.0(119)	X X	74.4(152)	X X	74.5(117)	74.2(48)
All beef	70.6(529)	80.5(2)	73.4(279)	67.8(252)	73.6(260)	66.3(203)	69.8(374)	73.1(132)
All pork	76.4(516)	....	77.7(169)	75.8(347)	77.9(210)	75.3(300)	76.4(510)	....
All lamb	67.2(399)	68.5(18)	80.7(135)	71.4(282)	80.7(135)	71.4(272)	75.4(362)	68.1(55)
All lean beef	70.9(375)	....	72.6(195)	68.9(180)	73.2(176)	67.2(133)	70.5(266)	72.5(84)
All lean pork	75.8(245)	....	74.0(41)	76.1(204)	78.1(49)	75.2(196)	75.8(245)	....
All lean lamb	74.0(132)	68.2(9)	....	73.9(141)	....	73.9(136)	75.0(114)	69.3(27)
All 35-50% fat beef	70.0(154)	80.5(2)	74.6(84)	65.0(72)	74.6(84)	64.6(70)	68.3(108)	74.2(48)
All 35-50% fat pork	75.2(178)	....	74.6(35)	75.4(143)	74.2(68)	75.5(104)	75.0(172)	....
All 35-50% fat lamb	69.2(132)	65.4(9)	....	69.0(141)	....	69.0(136)	69.4(113)	67.2(28)
All ground beef	65.5(151)	80.5(2)	....	65.7(153)	X X	65.5(150)	65.7(153)	....
All ground pork	76.4(224)	....	82.2(41)	75.1(183)	82.3(42)	75.1(182)	76.4(224)	....
All ground lamb	64.7(332)	68.5(18)	81.7(68)	71.4(282)	X X	71.4(272)	74.4(295)	68.1(55)

Levels of consideration	Type of package						
	307 x 113 can	307 x 306 can	MSAT80 cellophane-coated side outside	Wrapped MSAT80 cellophane-coated side outside	Cellophane-pliofilm laminate	Cellophane-polyethylene laminate	Cellulose acetate-pliofilm laminate
All meat	75.8(228)	70.9(256)	71.9(59)	77.7(41)	75.6(631)	75.6(24)	68.8(32)
All lean meat	74.5(118)	72.3(130)	60.6(10)	....	75.1(390)	75.3(12)	68.5(16)
All 35-50% fat meat	73.8(68)	69.5(126)	60.5(10)	....	74.5(185)	75.9(12)	69.1(16)
All 25-35% fat meat	82.7(42)	....	77.7(39)	77.7(41)	82.8(56)	....	....
All ground lean	75.0(9)	72.3(130)	60.6(10)	....	76.7(80)	75.3(12)	68.5(16)
All cut lean	74.4(109)	....	....	....	74.6(304)	....	....
All ground 35-50% fat	69.9(8)	69.5(126)	60.5(10)	....	75.0(84)	75.9(12)	69.1(16)
All cut 35-50% fat	74.3(60)	....	....	....	74.2(101)	....	....
All beef	74.1(114)	66.5(68)	....	....	73.0(256)	69.9(12)	63.6(20)
All pork	76.3(70)	73.7(84)	67.8(21)	75.3(10)	67.8(247)	81.3(12)	77.5(12)
All lamb	79.2(44)	71.5(104)	74.2(38)	78.4(31)	78.7(128)	....	....
All lean beef	73.7(78)	68.0(36)	....	....	73.0(196)	70.5(6)	63.5(10)
All lean pork	76.0(32)	73.5(42)	59.2(6)	....	76.8(153)	80.1(6)	77.0(6)
All lean lamb	75.1(8)	74.3(52)	62.8(4)	....	79.0(41)	....	....
All 35-50% fat beef	75.0(36)	64.5(32)	....	....	73.3(60)	69.3(6)	63.7(10)
All 35-50% fat pork	73.4(24)	74.0(42)	62.3(6)	....	75.7(84)	82.5(6)	78.2(6)
All 35-50% fat lamb	69.9(8)	68.8(52)	57.5(4)	....	74.0(41)	....	....
All ground beef	79.0(1)	66.5(68)	....	....	68.6(25)	69.9(12)	63.6(20)
All ground pork	83.9(9)	73.7(84)	65.5(16)	80.2(5)	78.5(68)	81.3(12)	77.5(12)
All ground lamb	77.8(69)	71.5(104)	71.8(23)	84.2(16)	78.3(106)	....	....

Notes: Numbers in parentheses show numbers of samples observed; .... = No observations; X = Insufficient observations.

a given quality level as the project progressed, this could account in part for the relatively high organoleptic ratings recorded for *low-fat* samples. This is mentioned as a possibility but not a probability and it should be borne in mind inasmuch as there might appear to the reader to be an incongruity in the relative ratings of *lean* and *low-fat* samples.

PER CENT GROSS WEIGHT LOSS—GROUND MEAT

Meat examined after one week of storage showed, for *beef*, high, for *pork*, low, and, for *lamb*, medium per cent gross weight loss. During the second week, the gross weight loss of *beef* decreased, that of *pork* increased slightly, and that of

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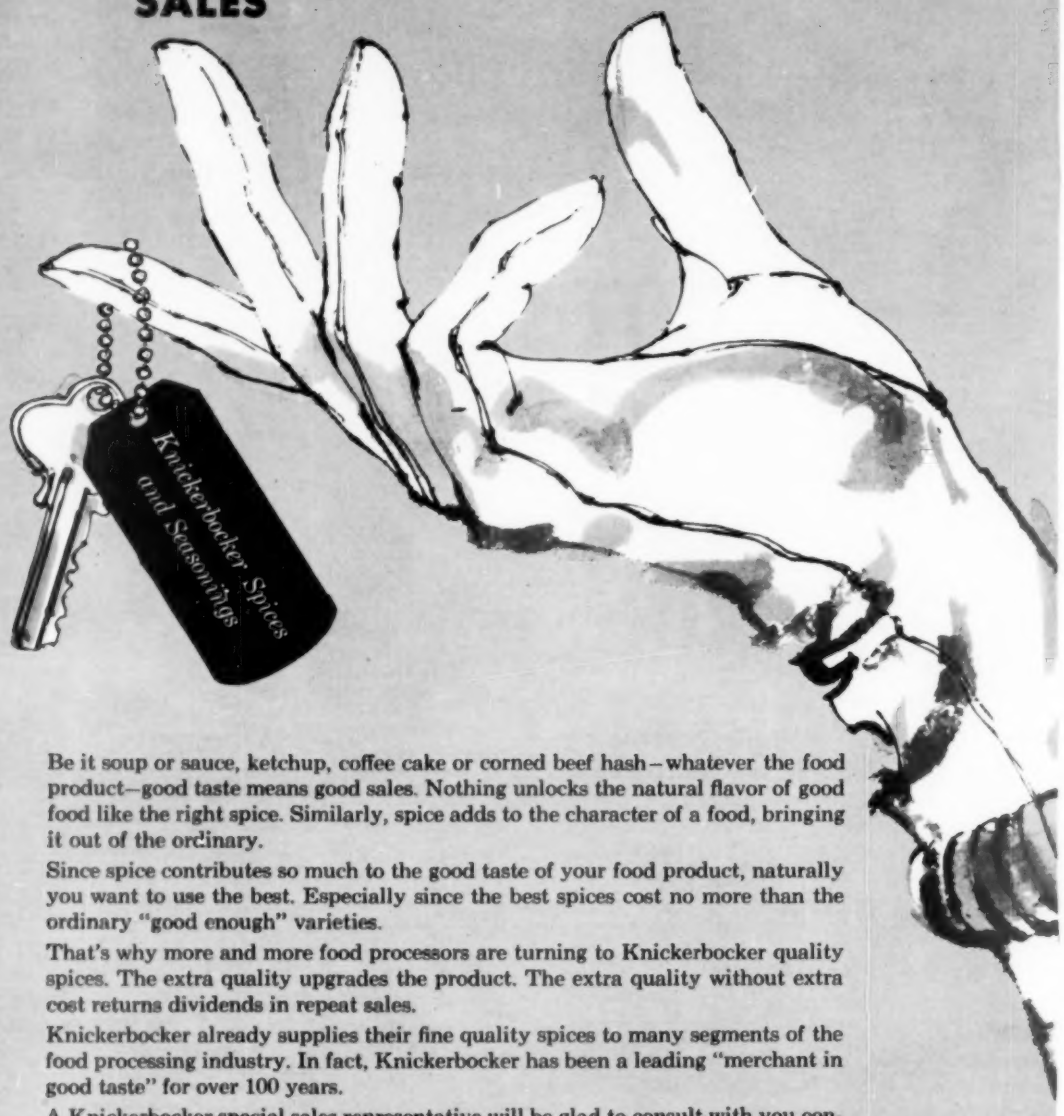

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lamb increased greatly. During the third week, the gross weight loss decreased in all types of meat, with the smallest gross weight loss appearing in *pork* and the highest in *lamb*.

Lean meat had greater gross weight loss in storage at temperatures below 35° than at temperatures between 35° and 39°; also greater than that of *fat meat* in storage at temperatures between 35° and 39°. Variation of temperature within the range, 32°–39°, had little effect upon gross weight loss of *fat meat* but above 35° loss in *lean meat* was less than that in *fat meat*. Below 35°, the three species of meat ranked from highest to lowest loss in the following order: *beef*, *pork*, *lamb*. Between 35° and 39° F., they ranked in the following order: *lamb*, *beef*, *pork*. At the higher temperatures, the gross weight loss of *lamb* was very high compared to those of either *beef* or *pork*.

In rough figures, based on insufficient data to be convincing, 6 different packaging conditions gave the following comparative percentages of gross weight loss:

	%
Non-packaged	15.5
MSAT80 cellophane, coated side inside	4.5
MSAT86 cellophane	2.2
Cellophane-pliofilm	1.0
Cellulose acetate-pliofilm	.65
Cellophane-polyethylene	.60

PER CENT NET WEIGHT LOSS

When *all meat* in all package types is considered as a sample, greater net weight loss appeared at the end of the second week of storage than at the end of either the first or the third week. (See Table 5). Net weight loss was somewhat less at the end of the first week than at the end of the fourth week.

After one week of storage, *beef* showed high, *pork*, medium, and *lamb*, low per cent net weight loss. *All species* of meat (beef, pork, and lamb, including, collectively, ground, cut, fat, and lean) showed maximum net weight loss at the end of the second week.

Ground meat showed greater net weight loss at the end of the first week than at the end of either the second or the third week. *Cut samples* showed net weight loss several times as great as that of *ground samples* at the end of the first week and the loss became still greater for *cut samples* during the second and third weeks.

Ground lean meat had slightly greater net weight loss in storage at temperatures below 35° than at temperatures between 35° and 39° F. At all temperatures, the net weight loss of *ground lean* meat was slightly greater than that of *ground fat* meat.

The net weight loss of *cut samples of beef* and *pork*, both lean and fat, was several times as great as that of *ground samples* at all temperatures between 32° and 37° F. Net weight loss of *cut samples* increased as storage temperature increased. *Cut samples of lamb* were not included in net weight loss tests.

The 3 species of meat ranked from highest to lowest net weight loss in the following order: at 32°–34° storage, *pork*, *beef*, *lamb*; at 35°–37° storage, *pork*, *lamb*, *beef*; at 38°–39° F. storage, *lamb*, *pork*, *beef*.

In rough figures, based on insufficient data to be convincing, eight different packaging conditions gave the following comparative percentages of net weight loss:

	%
Non-packaged	28.5
MSAT80 cellophane, coated side inside	5.0
MSAT86 cellophane	4.0
307 x 400 can	3.0
Cellophane-pliofilm laminate	1.7
307 x 306 can	1.3
Cellophane-polyethylene laminate	1.3
Cellulose acetate-pliofilm laminate	1.0

TABLE 5

Per cent net weight loss in relation to time in storage, temperature of storage, and type of package

Levels of consideration	Days in storage			Storage temperature			Type of package								
	6–8	14–16	17–21	32°–34°	35°–37°	38°–39°	307 x 400 can	307 x 306 can	Non-packaged	MSAT80 Cellophane-coated side inside	MSAT86 cellophane	Cellophane-pliofilm laminate	Cellophane-polyethylene laminate	Cellulose acetate-pliofilm laminate
All meat	3.49(168)	6.25(138)	4.35(150)	4.33(424)	4.04(431)	1.60(172)	2.74(60)	1.31(282)	28.43(72)	4.95(48)	4.10(87)	1.73(227)	1.28(66)	1.04(115)
All lean meat	3.47(80)	6.66(58)	4.60(71)	4.27(159)	3.28(177)	1.75(113)	4.09(13)	1.61(147)	31.75(19)	4.69(25)	3.67(31)	1.75(123)	1.44(36)	1.10(62)
All 35-50% fat meat	3.51(88)	5.95(80)	4.14(79)	4.37(265)	4.58(254)	1.30(59)	2.36(47)	.98(135)	27.24(53)	5.24(23)	3.68(66)	1.73(154)	1.08(30)	.96(53)
All 25-35% fat meat	....	....	....	....	....	....	....	....	....	....	....	....	....	....
All ground lean	2.57(69)	1.98(38)	2.03(59)	2.11(127)	1.97(158)	1.75(113)	....	1.63(147)	17.03(6)	4.69(25)	2.62(18)	1.41(111)	1.44(36)	1.10(62)
All cut lean	9.18(11)	15.56(20)	17.24(12)	12.82(32)	14.17(19)	....	4.09(13)	....	38.60(13)	....	5.13(13)	4.87(12)	....	....
All ground 35-50% fat	1.73(58)	1.20(32)	1.54(57)	2.01(154)	1.38(141)	1.30(59)	2.90(12)	.98(135)	18.42(6)	5.24(23)	2.63(18)	1.52(106)	0.66(23)	.96(53)
All cut 35-50% fat	6.93(30)	9.11(48)	10.86(22)	7.63(111)	8.56(113)	....	2.18(35)	....	28.40(47)	....	4.08(48)	2.18(48)	2.47(7)	....
All beef	4.35(89)	7.73(74)	5.35(88)	3.91(272)	.78(170)	.89(30)	3.52(25)	1.52(143)	28.00(38)	....	....	3.55(62)	1.91(110)	1.35(27)	1.03(67)
All pork	3.32(46)	4.52(58)	3.58(30)	7.05(97)	4.06(184)	1.06(65)	2.18(35)	.86(64)	28.92(34)	....	3.92(35)	1.84(95)	1.23(39)	1.00(22)	
All lamb	1.42(33)	4.58(6)	2.36(32)	1.62(55)	2.34(77)	2.32(77)	....	1.28(75)	....	4.95(48)	....	1.33(72)	....	1.08(26)	
All lean beef	5.12(46)	8.89(39)	6.11(44)	5.45(159)	.52(87)	.91(18)	4.09(13)	2.03(73)	31.75(19)	....	3.67(31)	2.23(54)	1.60(18)	1.11(36)	
All lean pork	1.06(16)	1.39(16)	1.63(10)	1.00(2)	1.01(57)	1.22(40)	....	.92(34)	....	....	....	1.14(31)	1.28(18)	1.20(11)	
All lean lamb	1.41(18)	5.73(3)	2.46(17)	1.78(18)	2.07(39)	2.42(55)	....	1.46(40)	....	4.69(25)	....	1.55(38)	....	1.01(15)	
All 35-50% fat beef	3.51(43)	6.44(35)	4.60(44)	3.14(133)	4.42(83)	.95(12)	2.90(12)	1.01(70)	23.20(19)	....	3.43(31)	1.61(56)	.84(9)	.95(31)	
All 35-50% fat pork	4.53(30)	5.72(42)	4.55(20)	4.10(4)	5.23(133)	.80(25)	2.18(35)	.79(30)	28.92(34)	....	3.92(35)	2.18(64)	1.18(21)	.79(11)	
All 35-50% fat lamb	1.44(15)	3.43(3)	2.26(15)	1.55(37)	2.61(38)	2.07(22)	....	1.07(35)	....	5.24(23)	....	1.08(34)	....	1.18(11)	
All ground beef	3.10(67)	1.59(34)	1.82(64)	2.19(220)	2.02(120)	.89(30)	2.90(12)	1.52(143)	17.73(12)	....	2.62(36)	1.39(85)	1.35(27)	1.03(67)	
All ground pork	.84(27)	1.00(30)	1.27(20)	1.07(6)	.83(102)	1.06(65)	....	.86(64)	....	....	....	1.13(60)	.95(32)	1.00(22)	
All ground lamb	1.42(33)	4.58(6)	2.36(32)	1.62(55)	2.34(77)	2.32(77)	....	1.28(75)	....	4.95(48)	....	1.33(72)	....	1.08(26)	

Notes: Numbers in parentheses show numbers of samples observed. .... = No observations.
Both lean and fat beef, fat pork and both lean and fat lamb showed higher net weight loss at 14–16 days than at 17–21 days. No cut lamb was included.

HUNTER a_L VALUE, TOP SURFACE, WHITE STANDARD

When *all meat* in all package types is considered as a sample, deterioration of red color occurred almost continuously during a storage period of 4 weeks. There was a slight improvement of red color during the second week but at the end of the third week the rating for redness was lower than at any previous time. The improvement during the second week was due to a marked improvement that occurred during that period in the *fat lamb* samples, which outweighed the moderate deterioration in red color which occurred in the *lean meat*. *Fat pork* samples experienced a startling recovery of red color during the third week of storage but this was not sufficient to outweigh the appreciable losses of red color experienced by other classes of samples. Samples in cans were responsible for

TABLE 6

Hunter a_L value, top surface of samples, in relation to variables in preparation, packaging, and storage of meat (white standard used)

Levels of consideration	Days in storage					
	0	1–3	6–8	13–15	20–23	27–32
All meat	16.94(64)	15.47(235)	14.08(278)	14.38(145)	13.99(151)	12.30(132)
All lean meat	18.57(29)	16.53(141)	14.75(173)	14.54(83)	14.04(71)	12.61(62)
All 35-50% fat meat	21.58(14)	13.60(94)	13.17(106)	14.16(62)	13.94(80)	12.00(70)
All 25-35% fat meat	11.69(21)	....	....	....	....	....
All ground lean	16.50(11)	16.34(58)	16.04(64)	14.86(19)	14.95(31)	15.22(24)
All cut lean	19.80(18)	16.79(83)	13.99(109)	14.45(52)	13.33(40)	10.99(38)
All ground 35-50% fat	....	12.87(56)	12.81(62)	11.43(30)	12.28(48)	12.70(23)
All cut 35-50% fat	21.56(14)	14.67(38)	13.67(44)	16.73(32)	14.54(50)	11.66(47)
All beef	21.44(28)	22.26(94)	17.97(135)	17.42(70)	17.28(72)	14.53(35)
All pork	12.42(22)	9.39(93)	9.46(96)	9.34(39)	14.31(55)	10.63(73)
All lamb	15.10(14)	13.40(48)	13.18(48)	13.5[illegible](36)	12.25(24)	14.01(24)
All lean beef	20.30(20)	25.08(54)	18.02(89)	17.[illegible]98)	17.91(34)	15.72(18)
All lean pork	16.50(4)	9.90(63)	9.99(60)	10.29(27)	9.33(25)	10.15(32)
All lean lamb	13.24(5)	14.83(24)	14.49(24)	14.19(18)	12.88(12)	14.58(12)
All 35-50% fat beef	24.31(8)	18.51(40)	17.45(46)	17.07(32)	16.72(38)	13.32(17)
All 35-50% fat pork	15.98(4)	8.32(30)	8.57(36)	7.19(12)	11.35(30)	11.02(41)
All 35-50% fat lamb	21.80(2)	12.00(24)	11.87(24)	13.65(18)	11.63(12)	13.46(12)
All ground beef	18.68(8)	18.38(42)	17.53(54)	14.90(25)	15.08(37)	14.53(35)
All ground pork	9.80(8)	10.52(24)	10.09(24)	9.13(12)	....	....
All ground lamb	13.46(7)	13.41(48)	13.18(48)	13.16(24)	12.25(24)	12.38(12)

Levels of consideration	Storage temperature			Storage light		Storage room humidity		Antioxidant	
	32°–34°	35°–37°	38°–50°	Light	Darkness	Normal	80–82%	Non-treated	.05%–.5% ascorbic acid added
All meat	15.82(369)	14.95(518)	12.91(796)	15.14(354)	13.90(1353)	15.62(365)	13.85(1206)	13.74(1472)	16.47(270)
All lean meat	16.25(174)	14.72(198)	13.97(587)	14.26(76)	14.62(787)	16.42(159)	14.26(700)	14.33(930)	19.40(48)
All 35-50% fat meat	15.45(195)	15.08(320)	10.02(209)	16.00(178)	12.91(566)	14.98(206)	13.28(506)	12.76(528)	15.89(222)
All 25-35% fat meat	....	....	....	....	....	....	....	11.39(14)	....
All ground lean	17.18(112)	14.35(153)	14.90(111)	18.85(2)	15.28(375)	10.36(11)	15.14(366)	15.29(384)	....
All cut lean	14.56(62)	15.98(45)	13.76(476)	14.20(174)	14.01(412)	16.14(148)	13.30(334)	13.58(520)	19.20(48)
All ground 35-50% fat	14.81(110)	11.49(155)	10.80(93)	....	12.34(366)	....	12.34(366)	10.46(216)	15.02(150)
All cut 35-50% fat	16.27(85)	18.46(165)	9.47(116)	16.00(178)	13.94(200)	14.98(206)	15.74(1610)	14.36(312)	17.61(72)
All beef	18.69(188)	18.15(234)	17.69(305)	19.70(206)	17.38(539)	19.70(225)	17.28(472)	18.89(481)	16.47(270)
All pork	11.64(93)	11.45(152)	8.77(380)	8.83(148)	10.30(478)	9.02(140)	10.13(398)	10.01(641)	....
All lamb	14.12(88)	13.30(132)	13.19(111)	....	13.44(336)	....	13.44(336)	13.50(350)	....
All lean beef	19.16(94)	17.75(66)	18.04(280)	19.72(86)	17.81(359)	18.82(105)	17.75(292)	18.06(403)	19.20(48)
All lean pork	10.71(35)	12.29(68)	9.43(246)	9.01(90)	10.39(260)	9.88(54)	9.99(240)	10.11(356)	....
All lean lamb	14.47(45)	14.18(64)	14.26(58)	....	14.32(168)	....	14.32(168)	14.29(173)	....
All 35-50% fat beef	18.22(94)	18.31(168)	15.57(22)	19.62(120)	16.53(180)	19.61(120)	16.53(180)	23.15(78)	15.89(222)
All 35-50% fat pork	12.20(58)	10.76(84)	8.33(134)	8.58(58)	10.19(218)	8.45(86)	10.35(158)	99.34(280)	....
All 35-50% fat lamb	13.75(43)	12.46(68)	12.00(53)	....	12.56(168)	....	12.56(168)	12.66(170)	....
All ground beef	17.21(163)	15.12(101)	16.40(51)	18.85(2)	16.38(309)	10.36(11)	16.25(300)	17.64(165)	15.02(150)
All ground pork	10.06(7)	10.21(87)	9.36(46)	....	9.92(144)	....	9.92(144)	9.83(147)	....
All ground lamb	13.03(52)	13.01(120)	12.93(107)	....	13.04(288)	....	13.04(288)	13.05(295)	....

Levels of consideration	Type of package							
	307 x 113 can	307 x 306 can	307 x 400 can	Non-packaged	MSAT86 cellophane	Cellophane-pliofilm laminate	Cellophane-polyethylene laminate	Cellulose acetate-pliofilm laminate
All meat	14.56(264)	14.04(308)	15.90(70)	15.29(144)	15.18(90)	13.67(634)	14.91(28)	11.27(48)
All lean meat	14.52(170)	15.50(154)	15.73(32)	14.65(71)	18.10(36)	13.87(390)	14.52(12)	13.01(24)
All 35-50% fat meat	14.63(94)	12.40(154)	16.01(38)	17.62(52)	13.23(54)	13.37(244)	15.20(16)	9.50(24)
All 25-35% fat meat	....	....	....	11.71(21)	....	....	....	....
All ground lean	21.17(7)	15.50(154)	15.73(32)	25.38(9)	22.06(12)	13.51(88)	14.52(12)	13.01(24)
All cut lean	14.24(163)	....	....	13.09(62)	16.10(24)	13.97(302)	....	....
All ground 35-50% fat	....	12.40(154)	16.01(38)	36.31(6)	14.03(12)	11.01(86)	13.90(12)	9.50(24)
All cut 35-50% fat	14.62(94)	....		15.18(46)	13.24(42)	14.62(158)	19.15(4)	....
All beef	18.37(158)	16.42(144)	24.36(14)	27.96(28)	16.21(50)	18.08(286)	14.20(24)	....
All pork	8.90(106)	10.24(68)	12.63(40)	11.15(86)	13.02(24)	9.28(276)	19.15(4)	9.73(24)
All lamb	....	13.19(96)	16.67(16)	15.33(30)	15.17(16)	12.96(72)	....	12.79(24)
All lean beef	17.92(104)	17.90(72)	24.81(8)	26.30(14)	22.60(20)	17.77(188)	14.52(12)	....
All lean pork	9.16(66)	12.90(34)	11.00(16)	10.91(44)	10.89(8)	9.46(166)	....	11.66(12)
All lean lamb	....	14.40(48)	16.23(8)	14.30(13)	14.12(8)	13.80(36)	....	14.40(12)
All 35-50% fat beef	19.20(54)	14.93(72)	23.82(6)	29.20(14)	12.00(30)	18.67(98)	13.90(12)	....
All 35-50% fat pork	8.47(40)	7.61(34)	13.70(24)	11.97(28)	14.09(16)	9.00(110)	19.15(4)	7.81(12)
All 35-50% fat lamb	....	12.00(48)	17.15(8)	17.22(10)	16.23(8)	12.12(36)	....	11.20(12)
All ground beef	21.17(7)	16.42(144)	....	12.00(12)	18.02(24)	14.12(50)	14.20(24)	....
All ground pork	....	10.24(68)	....	9.80(8)	....	9.56(52)	....	9.73(24)
All ground lamb	....	13.19(96)	....	13.23(7)	....	12.96(72)	....	12.79(24)

Notes: Numbers in parentheses show numbers of samples observed. .... = No observations.
After 20 days all beef was ground samples. After 20 days all pork was cut samples.

accelerating early deterioration and retarding later deterioration. (See Table 6 [8]).

[8] While a rating of 12.0 or higher is considered to indicate desirable color in lamb or pork and a rating of 14.0 or higher in beef, these values have no special significance in Tables 6 and 7 because the rating values in those tables are means of groups, most of which cover a wide range.

Fat meat lost its red color more rapidly than *lean meat* during the early part of the storage period and, in spite of the strong recovery made by *fat lamb* during the second week and by *fat pork* during the third week, *fat meat* suffered a net loss of red color during 4 weeks of storage greater than that suffered by *lean meat*. The lowest rating for red color was shown by *fat pork* at the end of the second week of storage.

Early loss of red color followed by a recovery during the

TABLE 7

Hunter a_L value, top surface of samples, in relation to variables in preparation, packaging, and storage of meat (red standard used)

Levels of consideration	Days in storage						Storage temperature			
	0	1–2	6–8	13–15	20–22	23–33	32°–34°	35°–37°	38°–40°	41°–50°
All meat	13.53(25)	7.77(665)	8.02(619)	8.34(340)	10.66(178)	10.92(286)	11.14(587)	9.67(680)	6.98(1258)	8.50(763)
All lean meat	12.00(7)	8.35(397)	8.64(357)	8.95(211)	11.36(108)	10.99(150)	11.28(313)	10.07(259)	7.55(968)	9.80(372)
All 35-50% fat meat	22.23(4)	6.67(140)	7.75(177)	7.43(129)	9.58(70)	10.89(136)	12.18(227)	9.83(276)	4.85(235)	6.80(217)
All 25-35% fat meat	11.82(14)	7.08(128)	6.01(85)	....		....	5.22(47)	6.09(45)	6.07(55)	7.85(174)
All ground lean	12.00(7)	8.33(280)	8.80(218)	8.09(131)	9.85(62)	10.72(78)	10.55(254)	9.01(217)	7.72(620)	8.03(114)
All cut lean	....	8.41(117)	8.39(139)	10.24(80)	13.38(46)	11.41(72)	14.43(59)	15.51(42)	7.25(348)	10.58(258)
All ground 35-50% fat	....	5.55(105)	5.96(129)	5.09(93)	7.24(45)	9.22(57)	10.33(149)	6.71(210)	4.85(235)	4.66(110)
All cut 35-50% fat	22.23(4)	10.01(35)	12.54(48)	13.47(36)	13.79(25)	12.10(79)	15.70(78)	13.78(166)	....	9.02(107)
All beef	22.23(4)	9.00(172)	9.63(195)	9.93(109)	11.16(109)	11.69(34)	11.91(235)	12.38(229)	7.35(436)	14.30(108)
All pork	....	7.13(188)	7.32(165)	8.31(84)	10.50(33)	11.00(178)	12.16(164)	10.87(181)	5.58(341)	7.74(292)
All lamb	11.90(21)	7.44(305)	7.27(259)	7.19(147)	9.28(36)	10.43(74)	9.28(188)	6.57(270)	7.64(481)	7.40(363)
All lean beef	....	8.70(142)	8.85(147)	9.74(78)	11.34(73)	12.30(17)	11.62(132)	12.13(61)	7.31(418)	14.30(108)
All lean pork	....	7.80(109)	7.51(85)	8.57(49)	12.74(14)	10.70(92)	12.80(72)	12.04(74)	6.52(187)	7.68(164)
All lean lamb	12.00(7)	8.45(146)	9.15(125)	8.32(84)	10.49(21)	11.04(41)	9.86(109)	7.88(124)	8.36(363)	8.41(100)
All 35-50% fat beef	22.23(4)	10.50(30)	11.99(48)	10.40(31)	10.79(36)	11.06(17)	12.28(103)	12.47(168)	8.30(18)	....
All 35-50% fat pork	....	5.84(45)	7.78(62)	7.93(35)	8.85(19)	11.32(86)	14.41(65)	11.08(89)	3.54(99)	7.80(128)
All 35-50% fat lamb	....	5.50(65)	4.67(67)	7.27(63)	7.60(15)	9.67(33)	9.53(59)	5.16(119)	5.43(118)	5.36(89)
All ground beef	....	7.77(78)	9.77(92)	8.45(44)	9.74(52)	11.68(34)	11.05(216)	10.64(109)	6.89(156)	....
All ground pork	....	7.18(115)	4.99(72)	4.80(45)	5.04(19)	7.77(39)	8.58(57)	7.89(95)	5.26(248)	3.16(35)
All ground lamb	12.06(14)	7.27(263)	17.48(225)	7.00(135)	9.28(36)	10.50(62)	9.36(154)	6.37(244)	7.64(481)	7.36(276)

Levels of consideration	Pattern or temperature		Storage light		Storage room humidity		Antioxidant	
	1-temp.	20 hours room temp.	Light	Darkness	Normal	80–85%	Non-treated	.05–.10% ascorbic acid added
All meat	8.72(3318)	9.75(38)	8.48(937)	8.55(2439)	9.39(846)	8.40(1774)	8.63(3048)	10.93(244)
All lean meat	9.11(1970)	9.53(36)	9.10(420)	8.67(1586)	10.97(327)	8.65(989)	8.94(1811)	12.15(122)
All 35-50% fat meat	8.57(1041)	13.30(2)	9.84(210)	8.32(853)	10.86(212)	8.08(785)	8.60(916)	9.78(122)
All 25-35% fat meat	6.69(307)	....	6.69(307)	....	6.69(307)	....	6.92(321)	....
All ground lean	8.84(1260)	9.53(36)	5.64(128)	8.59(1168)	7.39(67)	8.88(657)	8.91(1223)	8.67(50)
All cut lean	9.60(710)	....	10.62(292)	8.89(418)	11.90(260)	8.19(332)	9.00(588)	14.58(72)
All ground 35-50% fat	6.39 688)	13.30(2)	3.49(44)	6.73(666)	5.14(19)	6.62(641)	6.75(635)	5.18(50)
All cut 35-50% fat	12.82(353)	....	11.53(166)	13.97(187)	11.42(193)	14.57(144)	12.78(281)	12.95(72)
All beef	10.36(1032)	10.31(12)	12.11(330)	9.53(714)	12.03(358)	10.16(465)	9.83(851)	13.77(144)
All pork	8.37(991)	....	6.11(322)	9.46(669)	7.70(253)	8.86(527)	8.36(990)	....
All lamb	7.67(1295)	9.44(26)	6.95(285)	7.31(1056)	7.19(235)	7.94(782)	8.00(1207)	6.93(100)
All lean beef	9.68(745)	9.72(10)	11.66(222)	8.82(533)	11.60(250)	9.26(286)	9.13(634)	14.58(72)
All lean pork	8.69(508)	....	6.23(120)	9.45(388)	10.14(54)	8.66(296)	8.66(507)	....
All lean lamb	8.82(717)	9.44(26)	6.24(78)	8.10(665)	6.09(23)	8.21(407)	8.97(670)	8.67(50)
All 35-50% fat beef	12.14(287)	13.30(2)	13.02(108)	11.62(181)	13.02(108)	11.60(179)	11.87(217)	12.95(72)
All 35-50% fat pork	8.68(383)	....	6.48(102)	9.47(281)	8.49(99)	9.11(231)	8.68(383)	....
All 35-50% fat lamb	5.70(371)	....	....	5.96(391)	11.14(5)	5.76(375)	6.27(316)	5.18(50)
All ground beef	9.76(505)	10.31(12)	6.63(18)	9.85(499)	8.07(44)	10.71(324)	9.74(517)	....
All ground pork	6.13(443)	....	3.90(128)	7.04(315)	4.11(66)	6.30(228)	6.13(443)	....
All ground lamb	7.66(1155)	9.44(26)	6.77(181)	7.24(1020)	7.14(131)	6.93(746)	8.00(1060)	6.93(100)

Levels of consideration	Type of package										
	307 x 113 can	307 x 306 (all ground) can	307 x 400 (all cut) can	Non-packaged	MSAT80 cellophane-coated side inside	MSAT80 cellophane-coated side outside	Wrapped MSAT80 cellophane-coated side outside	MSAT86 cellophane	Cellophane-pliofilm laminate	Cellophane-polyethylene laminate	Cellulose acetate-pliofilm laminate (all ground)
All meat	8.86(451)	8.52(509)	17.84(70)	8.33(707)	9.72(88)	5.54(164)	5.74(79)	12.90(62)	9.39(949)	8.72(28)	9.04(48)
All lean meat	8.96(256)	9.04(278)	18.13(32)	8.60(585)	10.83(44)	7.15(42)	....	12.47(28)	9.62(590)	6.94(12)	10.80(24)
All 35-50% fat meat	9.61(135)	7.91(231)	18.20(38)	6.85(86)	8.62(44)	3.92(44)	....	13.25(34)	8.97(320)	10.03(16)	7.30(24)
All 25-35% fat meat	7.80(60)	....	....	7.35(36)	....	5.60(78)	5.74(79)	....	9.46(39)	....	....
All ground lean	9.87(53)	9.04(278)	....	8.89(508)	9.16(36)	7.15(42)	....	8.25(12)	9.85(233)	6.94(12)	10.80(24)
All cut lean	8.42(203)	....	18.13(32)	6.72(77)	18.38(8)	....	....	15.60(16)	9.47(357)	....	....
All ground 35-50% fat	X X	7.91(231)	....	5.27(48)	5.97(36)	3.92(44)	....	7.22(12)	6.49(182)	6.02(12)	7.30(24)
All cut 35-50% fat	10.72(93)	....	18.20(38)	8.85(38)	20.52(8)	....	....	16.52(22)	12.25(138)	22.13(4)	
All beef	9.91(201)	11.43(198)	24.82(8)	8.32(146)	....	....	....	11.91(32)	11.07(362)	6.49(24)	....
All pork	7.70(115)	6.22(101)	18.38(50)	6.16(222)	19.42(16)	3.96(56)	4.71(18)	16.70(18)	8.49(318)	22.13(4)	8.52(24)
All lamb	8.29(135)	6.89(210)	10.91(12)	9.75(339)	7.56(72)	6.42(107)	6.05(61)	9.70(12)	8.21(260)	....	9.60(24)
All lean beef	9.19(147)	11.03(118)	24.60(4)	7.74(138)	....	....	....	12.77(16)	10.25(271)	6.94(12)	....
All lean pork	7.27(64)	8.19(51)	18.76(22)	6.81(128)	18.38(8)	6.00(18)	....	15.20(6)	8.55(191)	....	10.51(12)
All lean lamb	9.24(45)	7.26(109)	11.62(6)	9.70(319)	9.16(36)	8.01(24)	....	8.92(6)	9.86(128)	....	11.07(12)
All 35-50% fat beef	11.88(54)	12.04(80)	25.10(4)	18.19(8)	....	....	....	11.09(16)	13.52(91)	6.02(12)	....
All 35-50% fat pork	9.10(39)	4.23(50)	18.08(28)	5.52(72)	20.52(8)	1.58(19)	....	17.44(12)	8.38(127)	22.13(4)	6.30(12)
All 35-50% fat lamb	7.16(42)	6.48(101)	10.22(6)	7.72(6)	5.97(36)	5.93(24)	....	10.48(6)	5.65(102)	....	8.13(12)
All ground beef	X X	11.43(198)	....	8.33(115)	....	....	....	7.73(24)	10.43(84)	6.49(24)	....
All ground pork	X X	6.22(101)	....	6.81(128)	....	3.66(46)	3.41(8)	....	7.54(101)	....	8.52(24)
All ground lamb	8.64(111)	6.89(210)	....	9.70(319)	7.56(72)	6.45(77)	5.19(31)	....	8.09(249)	....	9.60(24)

Notes: Numbers in parentheses show numbers of samples observed. .... = No observations. X = Insufficient observations.

second week, then by further loss was shown by *cut samples* whereas *ground samples* showed some recovery during the third and fourth weeks. The net loss of red color in *ground samples* was relatively small.

Variation in storage temperature between 33° and 44° F. made practically no difference in red color retention by *ground samples of pork* and *lamb*. In *ground samples of beef*, red color was retained distinctly better at temperatures below 35° than at temperatures between 35° and 44° F.

Cut samples of beef showed somewhat better color when stored in the light than when stored in darkness. The reverse was indicated in *cut samples of pork*. Each of these effects was more pronounced in *fat meat* than in *lean meat*.

Cut samples of beef showed somewhat better color when stored under normal conditions of humidity than when stored under conditions of 80–82% relative humidity. The reverse was indicated in *cut pork* samples. Each of these effects was more pronounced in *fat meat* than in *lean meat*.

Cut samples of lean beef had slightly better color when treated with .05–.10% ascorbic acid than when not treated with ascorbic acid but *fat samples of beef* had better color when not treated with ascorbic acid than when treated with .05–.10% ascorbic acid. Pork and lamb were not evaluated in respect to this factor.

When *all meat*, *lean meat*, and *fat meat* each is considered separately as a sample, the meat in the different packages ranked from best to poorest in color in the following order:

All meat:

1. 307 x 400 can.
2. No package (short storage period).
3. MSAT86 cellophane.
4. Cellophane-polyethylene laminate.
5. 307 x 113 can.
6. 307 x 306 can.
7. Cellophane-pliofilm laminate.
8. Cellulose acetate-pliofilm laminate.

Lean meat:

1. MSAT86 cellophane.
2. 307 x 400 can.
3. 307 x 306 can.
4. No package (short storage period).
5. 307 x 113 can.
6. Cellophane-polyethylene laminate.
7. Cellophane-pliofilm laminate.
8. Cellulose acetate-pliofilm laminate.

Fat meat:

1. No package (short storage period).
2. 307 x 400 can.
3. Cellophane-polyethylene laminate.
4. 307 x 113 can.
5. Cellophane-pliofilm laminate.
6. MSAT86 cellophane.
7. 307 x 306 can.
8. Cellulose acetate-pliofilm laminate.

The above ratings in respect to the following four packages may be regarded as doubtful because of inadequate data:

307 x 400 can.
MSAT86 cellophane.
Cellophane-polyethylene laminate.
Cellulose acetate-pliofilm laminate.

These relative standings of the different package types are undoubtedly influenced by the following facts:

(1) Only *cut samples* were evaluated in the 307 x 400 can.

(2) Except for 7 samples of *ground beef*, all 264 samples which were counted in 307 x 113 cans were *cut samples*.

(3) Only *ground samples* were counted in the 307 x 306 can and in cellulose acetate-pliofilm laminate and most of the samples counted in cellophane-polyethylene laminate were *ground samples*.

It is to be borne in mind that *cut samples* inherently gave higher ratings for red color than *ground samples*.

HUNTER a_L VALUE, BOTTOM SURFACE AND INTERIOR, WHITE STANDARD

Ratings for red color of the bottom surfaces of meat samples generally were lower than those of the top surfaces and the ratings of the interiors of samples were lower than those of the bottom surfaces.

As was true of the top surfaces, the ratings for red color of the bottom surfaces and interiors of the samples increased in value during the second week of storage in *cut samples* but decreased in *ground samples*.

As was true of the top surfaces, the ratings for red color of the bottom surfaces and interiors of the samples was higher when the meat was *not packaged* than when it was *packaged* in cellophane-pliofilm pouches.

HUNTER a_L VALUE, TOP SURFACE, RED STANDARD

When *all meat* in all packages is considered as a sample, improvement of red color occurred continuously during a storage period of 4 weeks, following a severe deterioration during the first 2 days of storage. At the end of 4 weeks, the red color rating was substantially lower than the rating at the time of packaging. (See Table 7).

Ratings in respect to a red standard, throughout the storage period, including those on packaging day, were appreciably lower than the ratings in respect to a white standard. Deterioration of red color in the initial days of storage produced a much greater change in rating in respect to the red standard than in rating in respect to the white standard; then the changes taking place after the first few days of storage were indicated as improvement in red color by ratings in respect to a red standard but as a deterioration in red color by ratings in respect to a white standard. Thus the ratings on the two different bases approached one another during the storage period but they did not attain coincidence at the end of 4 weeks.

Note: The results described above seem to indicate that, when a red standard is used, the Hunter Meter responds much better to the type of color which appears in samples packaged in vacuum cans than when a white standard is used. The overall pattern of color change, indicated when a red standard is used, corresponds much more closely to that of "canned" samples than does the pattern of change indicated when a white standard is used.

The highest percentage of increase in rating for red color after the first week occurred in *fat lamb* samples.

Following pronounced deterioration in red color during the first 2 days of storage, *ground beef and lamb* remained almost constant in red color until the end of 2 weeks, then improved materially during the third and fourth weeks.

Ground pork suffered a pronounced, progressive, deterioration in red color during the first 2 weeks of storage; then recovered to about the color rating it had during the first 2 days. *All other types* of samples had a much higher a_L value at the end of 4 weeks than they had during the first 2 days of storage.

Fat ground samples improved in red color during the third and fourth weeks of storage at a higher rate than *lean ground samples*.

Low-fat meat, on which records were kept only during the first week of storage, had lower ratings for red color than either *lean* or *fat meat*.

Cut samples consistently had higher ratings for red color than *ground samples* even though the a_L value of the former decreased during the fourth week of storage.

Cut fat samples consistently had higher ratings for red color than *cut lean samples* but the reverse was true of *ground samples*.

As storage temperature was increased from 32° to 50° F. the a_L value for *fat samples* was decreased. Ratings for red color of *lean meat* were at their minima at storage temperatures of 38°–40° F.

Cut meat tended to show a higher rating for red color at storage temperature above 40° than at storage temperature below 40° F. but this was not true of *ground meat*.

Based upon the intensity of red color throughout the storage periods, meat stored for 20 hours at 70° F. before being stored under refrigeration was somewhat better than meat put into refrigeration immediately after packaging.

Cut samples of beef showed better color when stored in the light than when stored in darkness. The reverse was indicated in *cut samples of pork* and in *ground meat* of all species.

Cut samples of beef, both lean and fat, showed better color when stored under conditions of normal humidity than when stored under 80–85% relative humidity. Inadequate data indicated the reverse to be true of *ground beef*. The indications in respect to *pork* and *lamb* are confused by poor distribution of data on *low-fat samples*.

Cut samples of beef, both lean and fat, showed better color when treated with .05–.10% of ascorbic acid than when no treatment was used. *Ground lamb* showed the reverse effect. *Pork*, *ground beef*, and *cut lamb* were not evaluated in respect to this factor.

When *all meat*, *lean meat*, and *fat meat* each is considered separately as a sample, the meat in the different packages ranked from best to poorest in color in the following order:

All meat:

1. 307 x 400 can.
2. MSAT86 cellophane.
3. MSAT80 cellophane, coated side inside.
4. Cellophane-pliofilm laminate.
5. Cellulose acetate-pliofilm laminate.
6. 307 x 113 can.
7. Cellophane-polyethylene laminate.
8. 307 x 306 can.
9. No package (short storage period).
10. MSAT80 cellophane, wrapped, coated side out.
11. MSAT80 cellophane, coated side out.

Lean meat:

1. 307 x 400 can.
2. MSAT86 cellophane.
3. MSAT80 cellophane, coated side inside.
4. Cellulose acetate-pliofilm laminate.
5. Cellophane-pliofilm laminate.
6. 307 x 306 can.
7. 307 x 113 can.
8. No package (short storage period).
9. MSAT80 cellophane, coated side out.
10. Cellophane-polyethylene laminate.

Fat meat:

1. 307 x 400 can.
2. MSAT86 cellophane.
3. Cellophane-polyethylene laminate.
4. 307 x 113 can.
5. Cellophane-pliofilm laminate.
6. MSAT80 cellophane, coated side in.
7. 307 x 306 can.
8. Cellulose acetate-pliofilm laminate.
9. No package (short storage period).
10. MSAT80 cellophane, coated side out.

The above ratings in regard to the following 6 package types may be regarded as doubtful because of inadequate data:

307 x 400 can.
MSAT86 cellophane.
MSAT80 cellophane, coated side inside.
Cellophane-polyethylene laminate.
Cellulose acetate-pliofilm laminate.
MSAT80 cellophane, wrapped, coated side out.

These relative standings of the different package types are undoubtedly influenced by the following facts:

(1) Only *cut samples* were evaluated in the 300 x 400 can.
(2) Only *ground samples* were evaluated in the 307 x 306 can and in the cellulose acetate-pliofilm pouch.
(3) Except for 4 *cut samples*, all 28 samples which were counted in cellophane-polyethylene laminate pouches were *ground samples*.

It is to be borne in mind that *cut samples* gave higher ratings for red color than *ground samples*.

HUNTER a_L VALUE, BOTTOM SURFACE AND INTERIOR, RED STANDARD

Ratings for red color of the bottom surfaces of meat samples were higher and those of the interiors of samples were lower than the ratings of the top surfaces.

Changes of a_L values of bottom surfaces of *ground meat* and *cut meat*, both lean and fat, in relation to time of storage, followed the same general pattern as changes of a_L values of top surfaces.

In *fat meat*, the pattern of change of interior red color in respect to time differed from that of top and bottom surface red color. Values of a_L of interiors of *fat samples* decreased progressively during the first 3 weeks of storage (*cut samples* more than *ground samples*) then increased during the fourth week. Values of a_L of top and bottom surfaces of *ground fat samples* decreased for 2 weeks, then increased while those of *cut fat samples* increased during the second and third weeks of storage.

Change of a_L value of interiors of samples, in respect to time, for *beef*, *pork*, and *lamb*, as distinguished from one another, assumed very irregular patterns, compared to those for the top and bottom surfaces. The indicated changes in rating for fat and lean of all three species of meat are tabulated below:

	First Week	*Second Week*	*Third Week*	*Fourth Week*
Lean beef	?	Increase	Increase	Increase
Fat beef	?	Decrease	Decrease	Increase
Lean pork	?	Decrease	Increase	Decrease
Fat pork	?	Decrease	Decrease	Increase
Lean lamb	Increase	Constant	Decrease	Constant
Fat lamb	?	Increase	Decrease	Increase

For *all three species of meat*, a_L values of top and bottom surfaces were lower in storage temperatures above 36° than in storage temperatures below 36° F. The same was true for interiors of samples of *beef* and *pork* but, for *lamb*, the a_L values of interiors of samples were higher in storage temperatures above 36° than in storage temperatures below 36°.

Based upon the intensity of red color throughout the storage periods, *ground beef and lamb* stored for 20 hours at 70° F. before being stored under refrigeration had better interior color than similar samples put into refrigeration immediately after packaging. In bottom surface color, however, practically no effect was indicated by this difference in pattern of storage temperature. Other types of meat were not evaluated in respect to this factor.

Data indicated no clear cut effect of either light or variation in humidity upon color rating of bottom surface or of interior of samples.

When *all meat, lean meat,* and *fat meat* each is considered separately as a sample, the meat in three different package types ranked from best to poorest in bottom surface and interior color as follows:

All meat:

Bottom surface.

1. 307 x 113 can.
2. No package (short storage period).
3. Cellophane-pliofilm laminate.

Interior.

1. No package (short storage period).
2. 307 x 113 can.
3. Cellophane-pliofilm laminate.

Lean meat:

Bottom surface.

1. 307 x 113 can.
2. No package (short storage period).
3. Cellophane-pliofilm laminate.

Interior.

1. No package (short storage period).
2. 307 x 113 can.
3. Cellophane-pliofilm laminate.

Fat meat:

Bottom surface.

1. 307 x 113 can.
2. No package (short storage period).
3. Cellophane-pliofilm laminate.

Interior.

1. 307 x 113 can.
2. No package (short storage period).
3. Cellophane-pliofilm laminate.

Some Factors Affecting Intensity of Flavor and Toughness of Chicken Muscle*

(Manuscript received August 28, 1958)

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PRECURSORS of chicken meat flavor are found almost entirely in the muscle *(19, 20)* from which they can be extracted by cold water *(19, 20, 22)*. The typical meat flavor does not exist as such in either the raw muscle or in the water extract of muscle, but can be developed in each by cooking *(19)*.

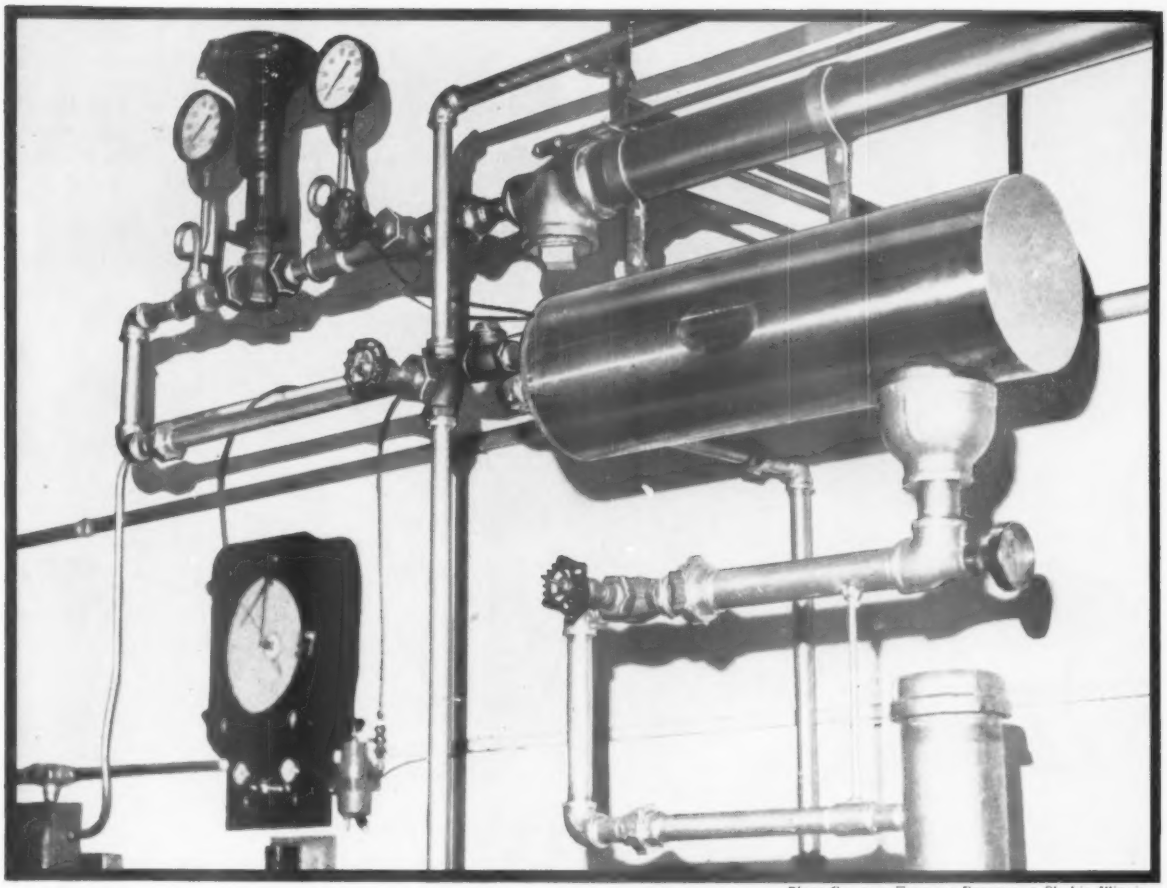
Little is known about actual meat flavor substances or about the flavor precursors. It would appear that a useful approach to the identification of flavor precursors would be to study the composition of muscle under various physiological conditions which might produce differences in flavor intensity of muscle when cooked.

As indicated by Lowe *(14)*, among the effects of maturation or increasing age in animals are increased depth of color of the muscles *(13)*, increased flavor intensity *(1, 6, 18)* and increased toughness *(10, 11, 12)*. While color, flavor, and toughness may possibly be related to age, probably through hormonal factors, it is not at all clear what the interrelationships are. The amount of connective tissue in muscle may be one factor in toughness connected with age *(10, 26)* but it is not necessarily the dominant one and even in young animals great variation in toughness has been found in carcasses of the same age *(15, 29)*.

Intensity of beef flavor was found by Barbella *et al. (1)* to increase with age in animals from 11 to 30 months, and by Nelson *et al. (18)* in animals from 8 to 32 months of age. In the latter study, tenderness appeared not to be greatly affected by age. Hiner and Hankins, however, found that tenderness of cooked beef muscle decreased with age in animals from 2.5 to 67 months old *(11)*. Jacobson and Fenton *(12)* also found decreasing tenderness of beef in animals from 7 to 19 months old. In this study flavor score increased from 7 months to 11 months old but decreased thereafter. In chickens Fry *et al.* found that 10-week old birds were more flavorful than 6-week old birds *(6)*.

Heavy exercise has been reported to produce slightly increased tenderness in beef as measured both by panel evaluation and by shear resistance *(3)*. Chemical analysis on the same muscle indicated that

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, May 28, 1958.



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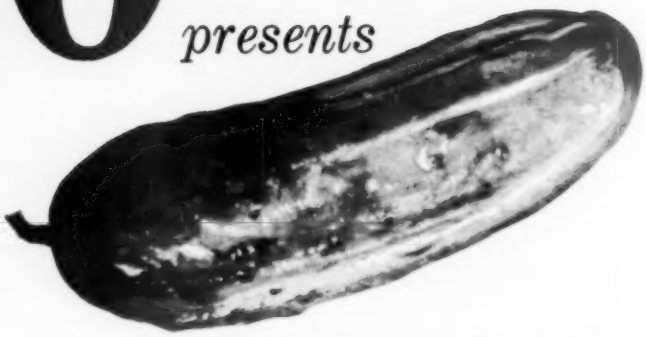

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exercise lowered the collagen content suggesting that hypertrophy had occurred without a corresponding increase in connective tissue *(16)*. Exercise appeared to have had no effect on flavor. The studies of Hiner *et al.* indicate, however, that individual muscles which were used more extensively had greater amounts of connective tissue and were tougher than those which were less active *(10)*.

A few studies on poultry have considered the effects of hormone treatments on flavor and tenderness. Estrogen (stilbestrol) treatment of the chicken has been reported to decrease tensile strength *(9)* or to increase tenderness *(24, 25)* of the muscle, whereas testosterone treatment increases the breaking strength and collagen content *(8, 9)*. The relationship of hormone treatments to flavor is less clear. Sturkie found no effect of estrogen treatment on flavor of chickens *(27)*. Fry *et al.*, reported a difference in flavor between stilbestrol-treated and untreated birds although no statement was made as to which had more flavor *(6)*. Swickard *et al. (28)* found no effect of stilbestrol on either tenderness or flavor of young turkeys.

Since it was not possible to predict from the available data which factors would have the greatest influence on intensity of flavor, the present exploratory investigation was undertaken. The effects of age, color of muscle, exercise, and implantation with stilbestrol or testosterone were studied as possible factors which might influence flavor intensity.

EXPERIMENTAL

Treatment groups

1. *Age.* Eleven White Leghorn hens, 19 months old, and 2 birds 34 months old were compared with young females 13 weeks old.

2. *Hormone treatment.* Young males (New Hampshire-White Leghorn crosses), 10 in each group were given implants of either 12 mg. stilbestrol or 25 mg. testosterone at 8 weeks and at 4 weeks before slaughter at 13 weeks of age. These were compared with an equal number of control birds.

3. *Exercise.* Young males were given exercise which consisted of walking 17 minutes per hour, 10 hours per day in a cylindrical cage which rotated at about 4½ r.p.m. This treatment was employed for 8 weeks prior to slaughter at the age of 13 weeks. The exercise was so severe in the first trial that only 4 out of the 10 birds were able to continue for the entire period. A second group was then started in which the severity of the exercise was gradually increased until the full exercise treatment was given for a total of 38 days before slaughter. This resulted in 6 survivors out of 10. These birds were compared with an equal number of controls.

Methods. Birds were killed and eviscerated in the usual way and chilled in chipped ice overnight before dissecting out muscles.

The samples used for flavor panels were the breast muscles of each bird (except the left deep pectoral muscle), and the thigh and right leg muscles. Samples were frozen and stored in polyethylene bags until they were prepared for the flavor panel.

The left deep pectoral and the left leg muscles were frozen, lyophilized and stored under nitrogen at about 0° F. Water extracts of these samples *(19)* were analyzed for non protein nitrogen *(4)* and reducing sugars *(7)*. Toughness of the cooked muscle used in the flavor evaluation was estimated using the method of Miyada and Tappel *(17)*, which consists of measuring the electrical energy required to grind the sample in a food grinder.

Flavor evaluations were made on broth prepared as follows: Samples were allowed to thaw at 10° C. for 24 hours. Three parts by weight of water to one part of muscle were added; the muscle was allowed to stand 15 minutes and was then cooked for one hour at 90° C. Water was added after cooking to restore the original volume. Fat was separated and discarded. Solid particles were removed by filtration through glass wool. The broth was served at 50° C. in black-lined demitasse cups to mask differences in color intensity. Random coding and serving orders were applied throughout the study.

The flavor evaluation was made by 6 to 8 judges who had been selected on the basis of their ability to detect flavor differences in chicken broths of varying concentrations. Judges were asked to select, from the pair submitted, the sample having the more intense chicken flavor. Three or four pairs of samples were submitted each day for a period of six weeks.

RESULTS AND DISCUSSION

Results of the flavor comparisons and objective measurements are shown in Table 1. Significance levels for flavor comparisons were determined by the method of Roessler *et al. (23)* and by the "t" test for all other determinations.

Dark muscle of older birds had a more intense flavor than dark muscle of younger birds. The judges, however, were unable to distinguish between breast muscle of the different age groups on the basis of flavor intensity. The total judgments on old versus young muscle comparisons, however, indicated a more intense flavor in the muscle of older birds than in that of younger birds (Table 1).

No significant separation could be made in the younger birds on comparing dark muscle with light muscle. However, in the older birds the dark muscle was definitely more flavorful than the light muscle and the combined judgments for young and old muscle indicated that this is generally true (Table 1).

The breast muscle of untreated control birds was selected as having more intense flavor significantly more often than that of estrogen treated birds. The totals of all judgments indicate that stilbestrol treatment tends to decrease flavor intensity (Table 1).

Testosterone treatment resulted in no detectable flavor differences (Table 1).

There was a tendency to ascribe more flavor to the breast muscle of the control birds when compared with that of exercised birds. From the totals of all judgments it would appear that exercise had little effect on flavor (Table 1).

There was a very definite increase in toughness of the cooked muscle wth age (Table 1). The breast muscle of the young birds was significantly tougher than the dark muscle but in the old birds the dark muscle was slightly tougher than the breast muscle. Exercise or hormone treatments did not have any significant effects on toughness during the period studied.

Although there was an increase in both flavor and toughness with age it would not be possible to propose a relationship between toughness and flavor from these results.

Since the typical flavor of chicken is produced in slightly acid solution and loses its character if the broth is neutralized or made alkaline *(2, 19)*, pH

TABLE 1

Sample	Flavor intensity No. of selections[1]		Toughness Joules/g.		Glucose mg./100 g. Dry muscle		NPN g./100 g. Dry muscle	
	Old	Young	Old	Young	Old	Young	Old	Young
Leg[2]	71[5]	13	27.15[5]	6.13	370[4]	193	1.15	1.17
Breast	49	35	22.76[5]	9.85	339[3]	272	1.71	1.75
Total	120[5]	48	24.95[5]	7.99	355[5]	232	1.36	1.39
	Leg	Breast	Leg	Breast	Leg	Breast	Leg	Breast
Old	70[5]	14	27.15[5]	22.76	370	339	1.15	1.71[5]
Young	45	39	6.13	9.85[4]	193	272[3]	1.17	1.75[5]
Total	115[5]	53	16.64	16.30	281	304	1.16	1.73[5]
	Stilb.	Control	Stilb.	Control	Stilb.	Control	Stilb.	Control
Leg	23	37	6.41	6.08	244	192	0.948	0.985
Breast	19.5	45.5[4]	9.60	8.70	277[4]	157	1.74	1.74
Total	42.5	81.5[5]	8.04	7.38	261[4]	175	1.34	1.38
	Test	Control	Test	Control				
Leg	28.5	31.5	5.88	5.54				
Breast	36	28	9.64	7.75				
Total	64.5	59.5	7.75	6.65				
	Exer.	Control	Exer.	Control				
Leg	28	26	6.78	6.34				
Breast	20.5	39.5[3]	12.69	10.10				
Total	48.5	65.5	10.03	8.38				

[1] Significance level according to Roessler *et al.* (*23*). Where no difference was found each sample was given a value of 0.5.
[2] "Leg" represents muscle from 2 thighs and 1 leg.
[3] Significant at 5% level.
[4] Significant at 1% level.
[5] Significant at 0.1% level.

values were determined on all broth samples. The mean pH values ranged from 6.1 to 6.4 for all experimental groups but no relationship to flavor intensity was found.

Pippen and Klose found that the neutralized ash of ice water extract of chicken contributed substantially to the flavor of the broth (*22*). In these experiments the mean ash content of broth per group varied from 177 to 230 mg./100 ml. but this variation was insufficient to produce a significant relationship to flavor intensity.

The mean moisture contents of muscle varied from 75.4% to 78.0% but no significant differences were found.

Crocker's hypothesis that meat flavor originates in the breakdown of muscle fiber proteins during cooking (*5*) does not appear to be borne out by the fact that flavor precursors can be extracted from the muscle with cold water and that the extracted muscle develops very little flavor on cooking (*19, 20, 22*). However, the occurrence of ammonia and hydrogen sulfide in distillate of chicken broth (*21*) suggests that breakdown of amino acid derivatives may be involved in the development of flavor. The non protein nitrogen determined on the water extracts of muscle in these experiments was not specific enough to be related to flavor but was characteristic of the type of muscle (Table 1).

The analyses for glucose or reducing sugar were significantly higher in the water extracts of dark muscle of the older birds than in that of the younger birds and thus varied with flavor intensity. However, in the stilbestrol treated birds the high values for reducing sugar were found in the breast muscle which had less intense flavor. Such values probably do not represent reducing sugar alone and the relationship of reducing sugar to flavor, if any, is thus not clear.

SUMMARY AND CONCLUSIONS

Dark muscle of old hens had a more intense flavor than dark muscle of 3-month-old pullets. In older birds the dark muscle had more intense flavor than the breast muscle. Differences in intensity of flavor could not be found between breast muscle of younger and older birds or between dark and light muscle of younger birds. Stilbestrol or exercise treatment tended to decrease flavor intensity of breast muscle but had no effect on dark muscle. Testosterone treatment was without effect on flavor.

Toughness of the cooked muscle increased with age in both dark and light muscle. Exercise or treatment with either stilbestrol or testosterone did not affect the toughness of muscle during the period studied.

The factor best related to differences in flavor intensity is *age* in dark muscle. The most useful comparisons in studying composition of muscle extracts for flavor precursors would appear to be between dark muscle of older and younger birds or between dark and light muscle of old birds.

LITERATURE CITED

1. Barbella, N. G., Tannor, B., and Johnson, T. G. Relationship of flavor and juiciness of beef to fatness and other factors. *Proc. Am. Soc. An. Prod.*, 32nd Ann. Meet. 320 (1939).
2. Bouthilet, R. J. A note on the nature of a flavor constituent from poultry meat. *Food Technol.*, **3**, 118 (1949).
3. Bull, S. and Rusk, H. P. Effect of exercise on quality of beef. Ill. Agr. Expt. Sta. *Bull. 488* (1942).
4. Chibnall, A. C., Rees, M. W., and Williams, E. F. The total nitrogen content of egg albumen and other proteins. *Biochem. J.*, **37**, 354 (1943).
5. Crocker, E. C. Flavor of meat. *Food Research*, **13**, 179 (1948).
6. Fry, J. L., Bennett, G., and Stadelman, W. J. The effect of age, sex and hormonization on the flavor of chicken meat. *Poultry Sci.*, **37**, 331 (1958).

7. Hendrickson, R. L., Brady, D. E., Gehrke, C. W., and Brooks, R. F. Dehydrated pork studies. Removal of glucose by yeast fermentation. *Food Technol.*, **9**, 290 (1955).

8. Herrick, E. H. Tensile strength of tissues as influenced by male sex hormone. *Anat. Rec.*, 93, 145 (1945).

9. Herrick, E. H., and Brown, K. Lowered tensile strength and collagen levels in tissues following discontinuation of male sex hormone. *Poultry Sci.*, **31**, 191 (1952).

10. Hiner, R. L., Anderson, E. E., and Fellers, C. R. Amount and character of connective tissue as it relates to tenderness in beef muscle. *Food Technol.*, **9**, 80 (1955).

11. Hiner, R. L., and Hankins, O. G. The tenderness of beef in relation to different muscles and age in the animal. *J. Animal Sci.*, **9**, 347 (1950).

12. Jacobson, M., and Fenton, F. Effects of three levels of nutrition and age on the quality of beef. I. Palatability, cooking data, moisture, fat, and nitrogen. *Food Research*, **21**, 415 (1956).

13. Jacobson, M., and Fenton, F. Effects of three levels of nutrition and age on the quality of beef. II. Color, total iron content and pH. *Food Research*, **21**, 427 (1956).

14. Lowe, B. *Experimental Cookery*. 1955. Ch. 8 Meat and poultry. John Wiley and Sons, Inc. New York, N.Y.

15. Lowe, B., Crain, E., Amick, G., Riedesel, M., Peet, L. J., Smith, F. B., McClurg, B. R., and Shearer, P. S. Defrosting and cooking frozen meat. Iowa Ag. Exp. Sta. *Res. Bull. 385* (1952).

16. Mitchell, H. H. and Hamilton, T. S. Effect of long continued muscular exercise upon the chemical composition of the muscles and other tissues of beef cattle. *J. Agr. Research*, **46**, 917 (1933).

17. Miyada, D. S., and Tappel, A. L. Meat tenderization. I. Two mechanical devices for measuring texture. *Food Technol.*, **10**, 142 (1956).

18. Nelson, P. M., Lowe, B., and Helser, M. D. Influence of the animal's age upon the quality and palatability of beef. Part II. The roast beef, preparation, quality and palatability. Iowa Agr. Exp. Sta. *Bull. 272* (1930).

19. Peterson, D. W. The source of chicken flavor. *Chemistry of Natural Food Flavors*. The Quartermaster Food and Container Institute for the Armed Forces. May, 1957, p. 167.

20. Pippen, E. L., Campbell, A. A., and Streeter, I. V. Origin of chicken flavor. *J. Agr. Food Chem.*, **2**, 364 (1954).

21. Pippen, E. L., and Eyring, E. J. Characterization of the volatile nitrogen and volatile sulfur fractions of cooked chicken and their relation to flavor. *Food Technol.*, **11**, 53 (1957).

22. Pippen, E. L., and Klose, A. A. Effect of ice water chilling on flavor of chicken. *Poultry Sci.*, **34**, 1139 (1955).

23. Roessler, E. B., Baker, G. A., and Amerine, M. A. One-tailed and two-tailed tests in organoleptic comparisons. *Food Research*, **21**, 117 (1956).

24. Schnetzler, E. E., Andrews, F. N., and Hauge, S. M. The influence of thiouracil and stilbestrol in fattening poultry. *U.S. Egg and Poultry Mag.*, **51**, 554 (1945).

25. Stadelman, W. J., McCartan, C. M., Baum, E. L., and McLaren, B. A. Growth, processing and shrinkage of diethylstilbestrol treated fryers. *Poultry Sci.*, **30**, 512 (1951).

26. Strandine, E. J., Koonz, C. H., and Ramsbottom, J. M. A study of variations in muscles of beef and chicken. *J. Animal Sci.*, **8**, 483 (1949).

27. Sturkie, P. D. A comparison of the gains in weight, fat deposition and market quality of estrogen treated cockerels and capons. *Poultry Sci.*, **25**, 531 (1946).

28. Swickard, M. T., Montague, E. H., Dochterman, E. F., and Marsden, S. J. Palatability of experimental estrogen treated turkey fryers. *Poultry Sci.*, **31**, 126 (1952).

29. Wierbicki, E., Kunkle, L. E., Cahill, V. R. and Deatherage, F. E. The relation of tenderness to protein alterations during post mortem aging. *Food Technol.*, **8**, 503 (1954).

The Effect of Cold and Modified Atmosphere Storage on the Canning Quality of Cling Peaches

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IT IS A COMMON PRACTICE in California to process cling peaches within a day following harvest whenever possible. However, cold storage of the fresh fruit is of some importance in extending the canning season. Early varieties such as Fortuna may be stored for one to two weeks until other varieties are ready, in order to avoid a short run that would be involved otherwise. Later in the season, during peak harvest, there have been times when cannery capacity was below daily harvested tonnage, necessitating cold storage of the surplus. It is not uncommon now to store late varieties in order to extend the period of processing fruit cocktail. Maximum storage periods may be in excess of 30 days.

Cling peaches are harvested commercially when the fruit reaches a tree ripe condition. In California this is determined by the attainment of flesh color at least as yellow as that shown in Plate 10-K-3 of the Maerz and Paul *Dictionary of Color*. The flesh color standard was established in the Marketing Order some time after the work reported here had been completed.

There seems to be no literature on the influence of storage of cling peaches on the quality of the canned fruit. Information on freestone peaches may have some bearing on the problem. Culpepper and others *(4)* reported that freestone peaches stored 7 days at 32° F. (0° C.) and ripened at 75° F. (23.9° C.) in 4 days resulted in a canned product slightly higher in flavor and general acceptability than that from non-stored fruit. When the storage period was 14 days the canned product was nearly as good as that from non-stored fruit. If the peaches were ripened before storage, flavor and general acceptability deteriorated fairly rapidly. Several investigators *(5, 6, 7, 8)* have shown that freestone peaches deteriorate fairly rapidly in storage. The closer the storage temperature approaches the freezing point of the fruit the longer it can be held.

PROCEDURE

During the years 1947, 1948, and 1949 peaches were harvested from an orchard in Sutter County at two maturities, determined primarily by skin color. The fruits of maturity 1 had a greenish cast in the stem cavity and along the shoulders, but otherwise the surface was largely free from visible green color. Fruits of maturity 2 were free from visible green color and represented normal harvest maturity. Maturity 2 was estimated to be 3 to 4 days more advanced than maturity 1.

Following harvest the peaches were brought to Davis for canning. Reference lots were placed overnight at 50° F (10° C.) and canned the next day, usually less than 24 hours after harvest. Other lots were stored for specified times at temperatures of 31° F. or 32° F. (0° C.), 37° F. (2.8° C.), 42° F. (5.6° C.), and sometimes 50° F. (10° C.). Storage times up to 30 days were used at temperatures of about 32° F. (0° C.) and 37° F. (2.8° C.), except for the early variety Fortuna, where the storage problem is one of more limited time.

In 1947 Halford peaches were stored at 42° F. (5.6° C.) for 15 days prior to canning in modified atmospheres containing 5, 10, and 15% carbon dioxide. Atmospheres of the desired composition were obtained by mixing CO_2 and air by means of flowmeters and passing the mixture over fruit at a sufficient rate that less than 0.5% further build-up of CO_2 from respiration occurred. In 1948 Gaume peaches harvested at maturity 2 were stored for 10, 20, and 27 days in atmospheres where the oxygen content had been reduced to 2½ and 1%. These mixtures were obtained by mixing nitrogen with air. Flow rates over the stored peaches were sufficiently rapid to keep the CO_2 content of the exhaust air below 0.5%.

The canning procedure involved hand pitting, followed by lye dip peeling. Twenty ounces of fruit were weighed into each can, to which was added 10 ounces of 40% sucrose syrup. The cans were then exhausted at 180° F. (82.2° C.) for 12 minutes, sealed, and cooked at 212° F. (100° C.) for 25 minutes. This was followed immediately by a cooling period in cool running water. Each lot was given a number at the time of canning, representing its position in the season's program. The lot numbers were the only identification on the cover and were used in setting up the samples for tasting.

After a storage period of approximately 5 months, the lots were evaluated for flavor by a 3-person panel with extensive experience in tasting canned peach varieties. Each variety was tasted separately. Eight lots, selected and arranged randomly on the tasting table, constituted a tasting unit. All 3 persons tasted concurrently, but independently, until each had arrived at an opinion regarding each sample. A lot thus could be retasted and comparisons made between or among any of the 8 samples on the table. When finished, each taster filed his evaluations. After all the lots of a variety had been tasted in this manner, the entire procedure for the variety was repeated, furnishing a complete and entirely independent duplication. A sample of the variety of commercial maturity and processed on the day after harvesting was always included for reference. Rating was done on a theoretical scale of 1 to 25. The average of the 6 values obtained from the duplicate tasting of the 3 members has been used in this paper.

It was recognized that a procedure using numerical values as a measure of flavor changes, and relatively small panel was susceptible of certain errors. In such a procedure the degree of agreement among members of the panel with respect to the flavor value of a given sample and the degree of agreement among replications of the same sample by a panel member are of great importance. Table 1 presents representative data for

TABLE 1
Comparison of duplicate flavor ratings of each panel member

Lot No.	A		B		C	
	(1)	(2)	(1)	(2)	(1)	(2)
393	7	6	6	8	6	8
420	5	5	5	4	5	5
319	10	10	8	8	9	8
351	13	12	12	10	13	10
423	4	2	3	2	4	3
408	10	10	9	9	9	9
238	16	15	17	16	16	14
239	16	17	14	15	13	14
416	2	3	2	3	3	4
391	10	8	10	10	9	9

10 samples which show respectively the agreement among the panel members for each sample and the agreement between duplicate samples for each member. It is believed that the relatively good agreement among the panel members and between duplicate samples is related to the experience of the panel in tasting canning peach varieties. It is evident that the 3 observers were able to distinguish clearly among the samples and that their ratings were sufficiently consistent to indicate the direction of flavor changes with time and temperature of storage.

It must be emphasized that the values for flavor ratings have no necessary relation to consumer acceptance. Although changes in flavor rating do represent changes in acceptability to members of the panel, it must be clearly understood that no extrapolation beyond this group can be made; and no attempt has been made to do so.

Since none of the varieties used belonged to the highest aroma group, the highest flavor values recorded did not exceed about the middle range of the scale used.

Following tasting, pH of the syrup was determined using a Beckman pH meter and total acidity by titrating with 0.2 N NaOH to a pH of 7.0; pH readings were converted to H^+ concentration for easier comparison.

RESULTS

In 1947, two varieties, Halford and Phillips Cling were canned; in 1948, Fortuna, Gaume, and Stuart; and in 1949, Fortuna and Gaume.

Flavor. The effect of time of storage at 32° F. (0° C.) on the flavor ratings of the Halford and Phillips Cling canned in 1947, the Gaume and Stuart canned in 1948, and the Fortuna canned in 1949 are shown in Figure 1. All were harvested at maturity 2(M2). All five of these varieties show the same general pattern—that of a relatively rapid and regular decrease in flavor value as the storage time increases.

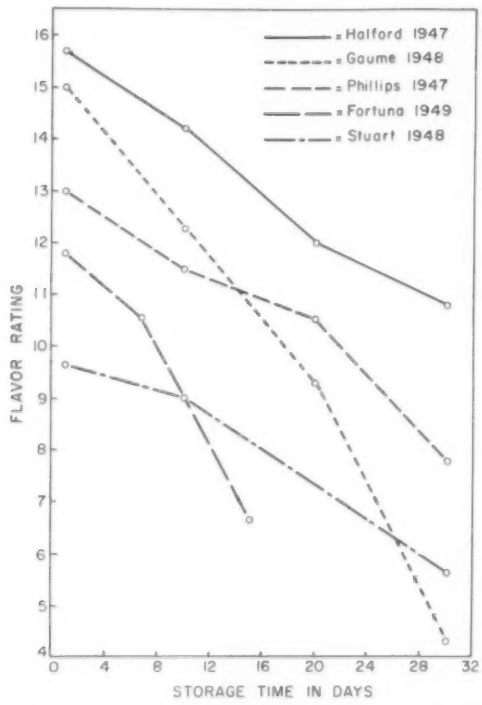

Figure 1. Flavor rating of 5 cling peach varieties harvested at M2 maturity and canned at different time intervals after storage at 32° F. (0° C.).

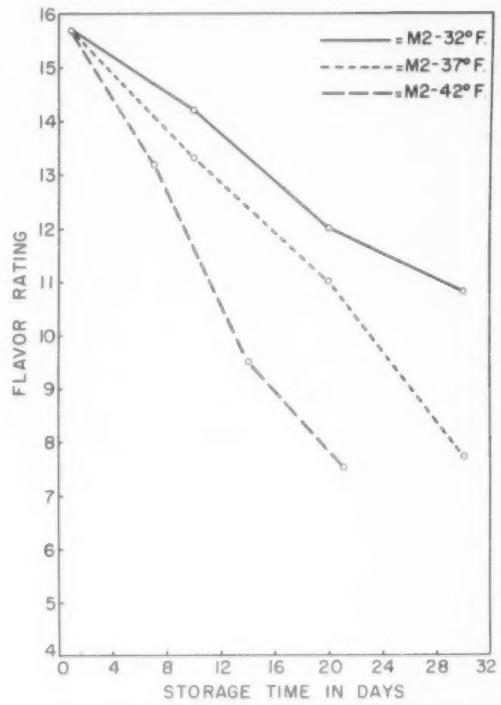

Figure 2. Flavor rating of Halford peaches harvested at M2 maturity and held at different storage temperatures before canning.

Although the same general pattern of flavor change is shown by all the varieties investigated, there seem to be differences in the rate of change. The Halford and the Gaume, the former canned in 1947, the latter in 1948, have essentially the same initial flavor rating; yet there is a wide difference in the rating at the end of the 30-day storage period. The flavor of Gaume has decreased at a much more rapid rate than has that of Halford. The Fortuna with an initial flavor value much below that of Gaume has a rate of loss of flavor value much the same. The Stuart with the lowest initial flavor value and the Halford with the highest show essentially the same rates of flavor decrease.

The effect of storage temperature on flavor change is shown in Figures 2 and 3. There is shown in Figure 2 the changes in flavor of maturity 2(M2) Halford peaches harvested in 1947 and stored at 32° F. (0° C.), 37° F. (2.8° C.), and 42° F. (5.6° C.) before canning. Flavor rating changed rapidly at all storage temperatures. The greatest rate of change was at 42° F. (5.6° C.) and the least at 32° F. (0° C.). The same degree of flavor loss was reached in 11 days at 42° F. (5.6° C.), 20 days at 37° F. (2.8° C.), and 28 days at 32° F. (0° C.).

The changes in flavor of maturity 1(M1) Halford peaches harvested in 1947 and stored at 32° F. (0° C.), 37° F. (2.8° C.), and 42° F. (5.6° C.) are shown in Figure 3. These data show the same general over-all pattern—a reduction in flavor ratings with time at all storage temperatures—as was shown for M2 fruit, although the changes were not so regular as with the latter maturity. The rates of flavor loss with the initial storage periods seem to be less with the M1 than with the M2 fruit.

The patterns of flavor behavior shown by Figures 1, 2, and 3 are representative of all the samples investigated. They indicate that peaches canned after storage suffer a reduction in flavor which is a function of both the time and temperature of storage. The data offer no evidence, however, regarding any interpretation of the relation between time or temperature of storage and flavor values.

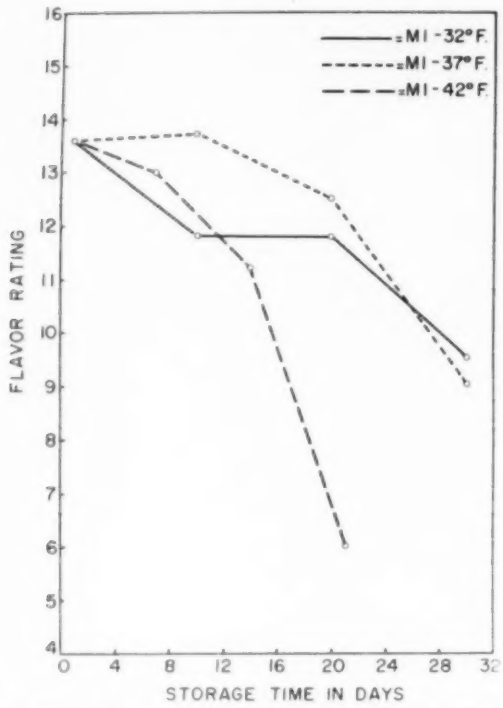

Figure 3. Flavor rating of Halford peaches harvested at M1 maturity and held at different storage temperatures before canning.

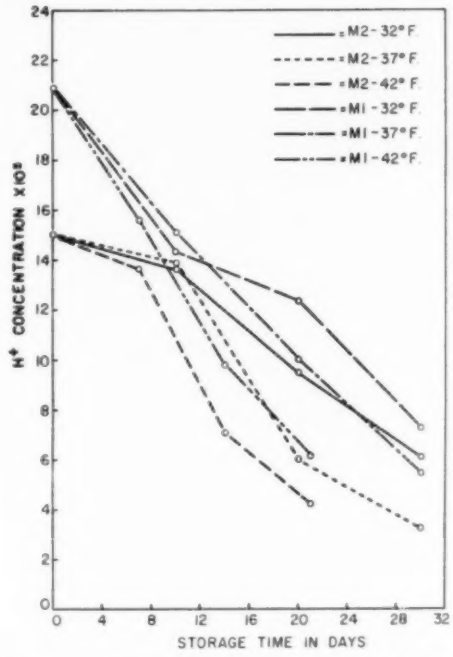

Figure 4. H⁺ concentration of syrup from Halford peaches harvested at 2 maturities and held at different storage temperatures before canning.

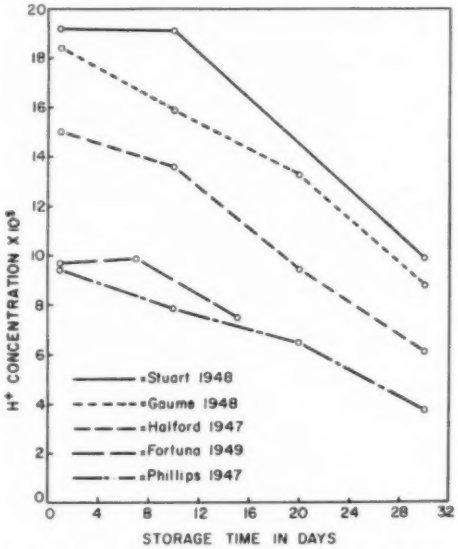

Figure 5. H⁺ concentration of syrup from 5 cling peach varieties harvested at M2 maturity and canned at different time intervals after storage at 32° F. (0° C.).

The flesh color of maturity 1 peaches of most varieties had a sufficient greenish cast to affect the grade when the fruit was canned the day following harvest. The green color disappeared progressively during storage and was not noted in canned fruit of any variety where storage had exceeded 15 days. The loss of green color was progressively more rapid at the higher storage temperatures.

The appearance of peaches other than color also was influenced by length of storage period and temperature. Storage for 20 days at 42° F. (5.6° C.) usually resulted in the canned fruit having a dull, "old" appearance in contrast to the usual bright appearance. A similar condititon was noted in peaches stored at 37° F. (2.8° C.) for 30 days, and to a lesser degree when the storage temperature was at or near 32° F. (0° C.). It seemed to make little difference whether the fruit was initially of M1 or M2 maturity.

H ion concentration. H⁺ concentration converted from pH readings of the syrup is shown in Figure 4 for Halford peaches in 1947. The H⁺ concentration was greatest initially in the M1 fruit. This was true without exception in all varieties studied. The rate of reduction in H⁺ concentration is progressively greater as the storage temperature is elevated from 32° F. (0° C.) to 37° F. (2.8° C.) to 42° F. (5.6° C.). Limited data at 50° F. (10° C.) indicate further acceleration of H⁺ reduction at this temperature. The rate of change seems to be a function of temperature rather than maturity as indicated by the comparable slopes of the M1 and M2 curves in all varieties tested. The magnitude of change in H⁺ concentration is impressive. At 37° F. (2.8° C.) M2 Halford peaches showed a reduction in excess of 75% in 30 days; M2 peaches stored at 42° F. (5.6° C.) had a reduction not greatly less than this in 20 days.

Figure 5 illustrates changes in H⁺ concentration of M2 peaches of the varieties tested following storage at 32° F. (0° C.). There is a wide range of H⁺ concentration between varieties. No doubt the differences reflect in part true differences between varieties. However, it is known that seasonal variations related to climate and other factors do occur, so that the varieties harvested in 3 separate years may not be comparable. For example, the initial reading of H⁺ concentration for M2 Fortuna peaches in 1948 was .00013, compared to .000097 in 1949. Similarly, Gaume in 1948 was .000184, and in 1949 it was .000147. These are the only two varieties repeated in the tests. Regardless of variety the percentage change in H⁺ concentration as shown in Figure 5 for peaches stored at 32° F. is quite similar.

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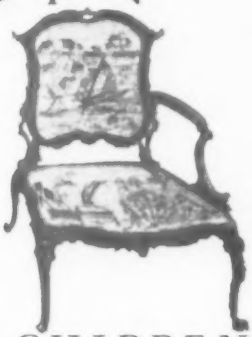

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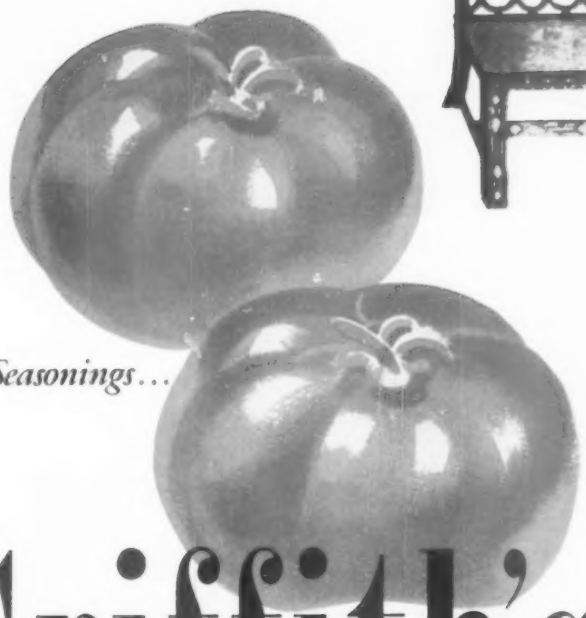

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Titratable acidity. Changes in titratable acidity with time and storage temperature are shown in Figure 6. The loss of acidity is very rapid, especially in the less mature fruit. The curves resemble quite closely those that indicate reduction in H^+ concentration, although the percentage reduction is not as great. In the fully mature peaches (M2) the same acidity was reached in about 17 days at 42° F. (5.6° C.) and in 19 days at 37° F. (2.8° C.) as in 30 days at 32° F. (0° C.). In the less mature peaches (M1) comparable figures are 17 days at 42° F. (5.6° C.), 25 days at 37° F. (2.8° C.), and 30 days at 32° F. (0° C.).

Changes in titratable acidity of 5 cling peach varieties harvested at full maturity and stored at 32° F. (0° C.) are shown in Figure 7. Acidity varies considerably between varieties, but all show a somewhat similar trend in rate of acid loss. The variety variability shown by the curves is not necessarily an indication of true differences. For example, Fortuna harvested in 1949 was somewhat lower in acid than in 1948, when it was quite comparable to Gaume of the same year. Gaume harvested in 1949 was also somewhat lower in acid than in 1948 and more nearly resembled Halford of 1947 in acidity.

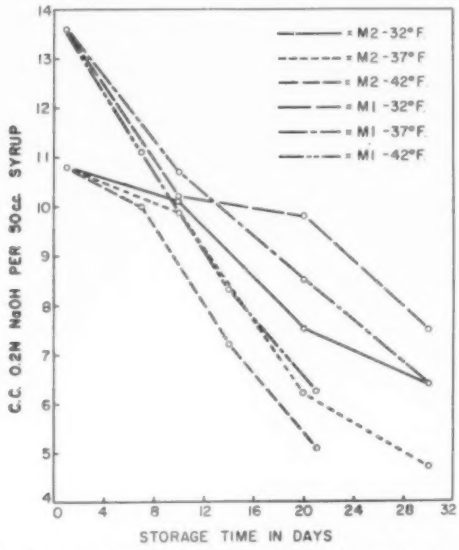

Figure 6. Titratable acidity of Halford peaches harvested at 2 maturities and held at different storage temperatures before canning.

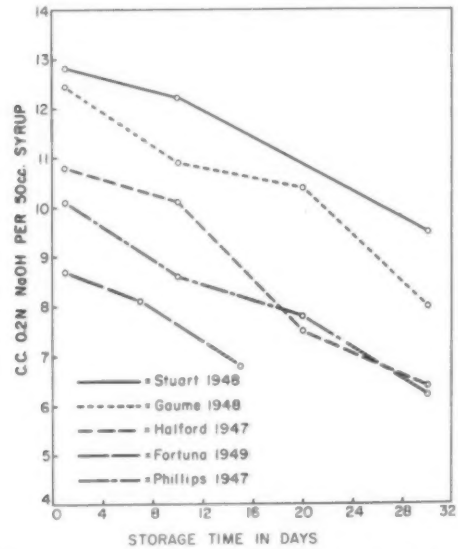

Figure 7. Titratable acidity of syrup from 5 cling peach varieties harvested at M2 maturity and canned at different time intervals after storage at 32° F. (0° C.).

The reasons for substantial variability in acidity of cling peaches from year to year are not known, but certainly climate can be an important factor. Temperatures in 1948 and 1949 for the 4 and 6 weeks' periods prior to harvest both of Fortuna and Gaume were compared. The diurnal range of temperature was found to be greater in 1948 when acidity was high. In the case of Fortuna, an early variety, the difference of about 3° F. (1.6° C.) between the two seasons was due to higher maximum temperatures in 1948. During the 4-week period prior to the harvest of Gaume the range in 1948 was 5° F. (2.8° C.) greater than in 1949. This was due mostly to lower minimum temperatures in 1948 although daily maximums also were 1.7° F. (0.9° C.) higher. Whether these differences in temperature range account in part or wholly for the greater acidity in 1948 is not known, but it is in agreement with the generally accepted idea that more spritely fruits are found under climatic conditions where diurnal temperature range is great.

Storage in modified atmospheres. It has been recognized for years that the storage life of many fruits may be extended by storage in atmospheres that have been modified by reducing the oxygen content, increasing the carbon dioxide content, or both. Allen *(1)* has shown that Levi cling peaches can be held without noticeable deterioration in flavor in an atmosphere of 11% CO_2 for 10 days at 45° F. (7.2° C.) or in one where the initial CO_2 of 30% gradually diminished over a 10-day period to 5%, also at 45° F. (7.2° C.). Claypool and Allen *(3)* have shown that Primrose, a freestone variety of peach, can be held for 10 days at 40° F. (4.4° C.) and 65° F. (18.3° C.) in atmospheres as low as 2.5% oxygen or as high as 10% CO_2.

In order to determine the influence of modified atmospheres on the rate of deterioration of cling peaches two sets of experiments were conducted. In 1947 Halford peaches of the two maturities previously indicated were held at 42° F. (5.6° C.) in air-CO_2 mixtures containing 5, 10, and 15% CO_2. These atmospheres were passed continuously over the fruit to avoid a build-up of volatile emanations from the peaches themselves. Processing following a 15-day treatment period was standard. In 1948 Gaume peaches of normal processing maturity (M2) were held for periods of 10, 20, and 27 days in atmospheres of 1 and 2½% oxygen at 42° F. (5.6° C.) prior to canning.

The appearance of Halford peaches stored in CO_2 atmospheres for 15 days was good. The data for flavor rating, H^+ concentration and titratable acidity, are shown in Table 2. Except for the M1 lot held in 5% CO_2, flavor deterioration was much more rapid than in fruit held in air for a comparable period of time. Flavor rating decreased as the CO_2 content of the air increased. It is not known whether flavor deterioration was discernible in the fresh fruit just prior to processing as no tasting was done. H^+ concentration and titratable acidity of the syrup of peaches stored in CO_2 atmospheres were not

TABLE 2

Flavor ratings of Halford peaches as influenced by the CO_2 content of the atmosphere and time in storage at 42° F. (5.6° C.)

Maturity	Days storage	Atmosphere % CO_2	Flavor rating	H^+ concentration	Titratable acidity cc. *N* NaOH for 10 100 cc.
1	1	air	14.3	.000175	12.7
1	14	air	11.2	.000098	8.3
1	15	5	12.0	.000083	7.8
1	15	10	3.3	.00006	6.4
1	15	15	2.3	.00009	8.8
2	1	air	15.7	.00015	10.9
2	14	air	9.5	.00007	7.2
2	15	5	4.7	.000051	5.9
2	15	10	2.7	.000065	7.3
2	15	15	1.3	.000071	7.4

greatly different than for air stored fruit. Actually the H^+ concentration readings of syrup from the 5% CO_2 storage lots of both maturities were less than the air or 15% CO_2 lots. The M1 10% CO_2 lot was also quite low in H^+ concentration and titratable acidity, but not the M2 10% CO_2 lot. Apparently the CO_2 atmospheres did not reduce the rate at which acids were used up. Neither does relative loss of acidity in CO_2 atmospheres give any key to the reason for rapid flavor deterioration in such atmospheres.

Gaume peaches stored in low O_2 atmospheres at 42° F. (5.6° C.) in 1948 for 10 days lost flavor at a comparable rate to those stored in air (Figure 8). However, after this period flavor deterioration was accelerated in the low oxygen lots with very low flavor ratings being recorded. H^+ concentration and titratable acidity changes seemed to follow temperature and be independent of the O_2 concentration in the atmosphere.

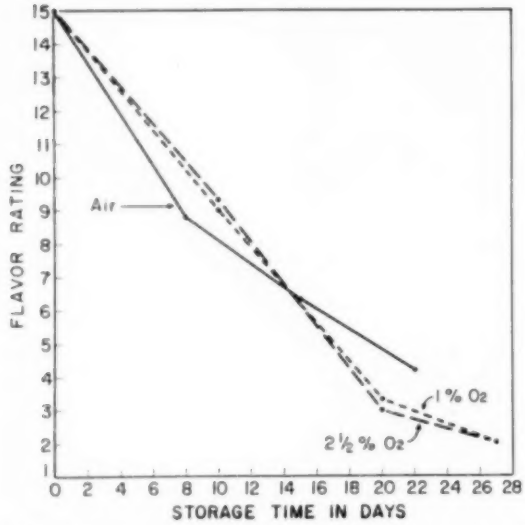

Figure 8. Flavor rating of Gaume peaches harvested at M2 maturity and canned at different time intervals after storage in low oxygen atmospheres at 42° F. (5.6° C.).

CONCLUSIONS

The data obtained during three consecutive calendar years involving two maturities of five varieties, two of which were repeated in two seasons, show that the flavor of cling peaches deteriorates rapidly during storage prior to canning. The rate of deterioration can be considerably reduced by holding fruit at 31° F.–32° F. (−.6° C. to 0° C.), but even at this temperature the rate is of considerable magnitude. All varieties at both maturities follow a similar pattern, although the actual slopes of curves indicating flavor loss are not identical.

Modified atmospheres involving a lowering of the oxygen content or an increase in the CO_2 content of the air not only failed to retard the rate of flavor deterioration but in most cases seemed to increase the rate at which flavor was lost.

Curves representing changes in H^+ concentration and titratable acidity show a rapid reduction of acidity during storage. Losses are less pronounced as the temperature is lowered, but even at 31° F. (−6° C.) as much as half of the acidity may be lost in 30 days. Modified atmospheres had little or no effect on acidity changes, indicating that the primary relationship was between temperature and the rate of change.

Although temperature has a similar effect on deterioration of flavor and loss of acidity, it cannot be assumed that loss of acidity is responsible for deterioration of flavor. It seems likely that both are associated with the aging processes of the fruit, the biochemistry of which is not yet known.

Climate appears to be at least in part responsible for differences in fruit quality and acidity from year to year. Those seasons where higher than average temperatures or greater than average differences between daily maximum and minimum temperatures occur may be associated with high flavor.

LITERATURE CITED

1. Allen, F. W. Carbon dioxide investigations: Influence of carbon dioxide atmospheres upon cherries, plums, peaches, and pears under simulated transit conditions. *Proc. Amer. Soc. Hort. Sci.*, **37**, 467–472 (1939).
2. Allen, F. W. Storage and shipping of stone fruits. *Ice and Refrigeration*, **113** (3), 19–24 (1947).
3. Claypool, L. L., and Allen, F. W. Modified atmospheres in relation to the transportation of deciduous fruit. *Proc. Am. Soc. Hort. Sci.*, **49**, 92–98 (1947).
4. Culpepper, C. W., Haller, M. H., Demaree, K. D., and Kock, E. J. Effect of picking maturity and ripening temperatures on the quality of canned and frozen Eastern-grown peaches. U. S. Dept. of Agr. *Tech. Bull. 1114*. 20 pp. (1955).
5. Fisher, D. V., and Britton, J. E. Maturity and storage studies with peaches. *Sci. Agr.*, **21**, 1–17 (1940).
6. Haller, M. H. Handling, transportation, storage and marketing of peaches. U. S. Dept. Agr. *Bibliographical Bull. 11*. 105 pp. (1952).
7. Haller, M. H., and Harding, P. L. Effect of storage temperatures on peaches. U. S. Dept. Agr. *Tech. Bull 680*. 32 pp. (1939).
8. Willison, R. S. Studies in maturity and cold storage of peaches. *Sci. Agr.*, **21**, 624–645 (1941).

Carob Varieties and Composition

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A PROGRAM OF RESEARCH on the utilization of fruit crops presently not widely grown in the United States has been undertaken by the U. S. Department of Agriculture's Western Utilization Research and Development Division in Albany, California. One of the most interesting crops studied under this program is carob, *Ceratonia Siliqua, L*, otherwise known as St. John's bread, and sometimes incorrectly called honey locust or algaroba *(10)*.

This evergreen tree has long been used extensively for shade and avenue planting throughout southern California and even as far north as the Sacramento Valley. Since ancient times the brown, sugar- and protein-rich pods of this leguminous tree have been used in European countries, chiefly for stock feed, and, recently, to an increasing degree, for human consumption.

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HISTORY, DESCRIPTION, AND UTILIZATION

Here in the United States the flesh of the pod is manufactured into various forms of human food. Imported kibbled carob is milled into a flour for human consumption as a food and as a pharmaceutical (Figure 1). The flour is used to alleviate diarrhea in both man *(1, 2, 8, 19)* and animal *(7)*. Its physiological activity is attributed to its high content of lignin, hemicellulose, and pectin. Carob flour as a food is sold in this country almost exclusively through health food stores as a substitute for chocolate. Home

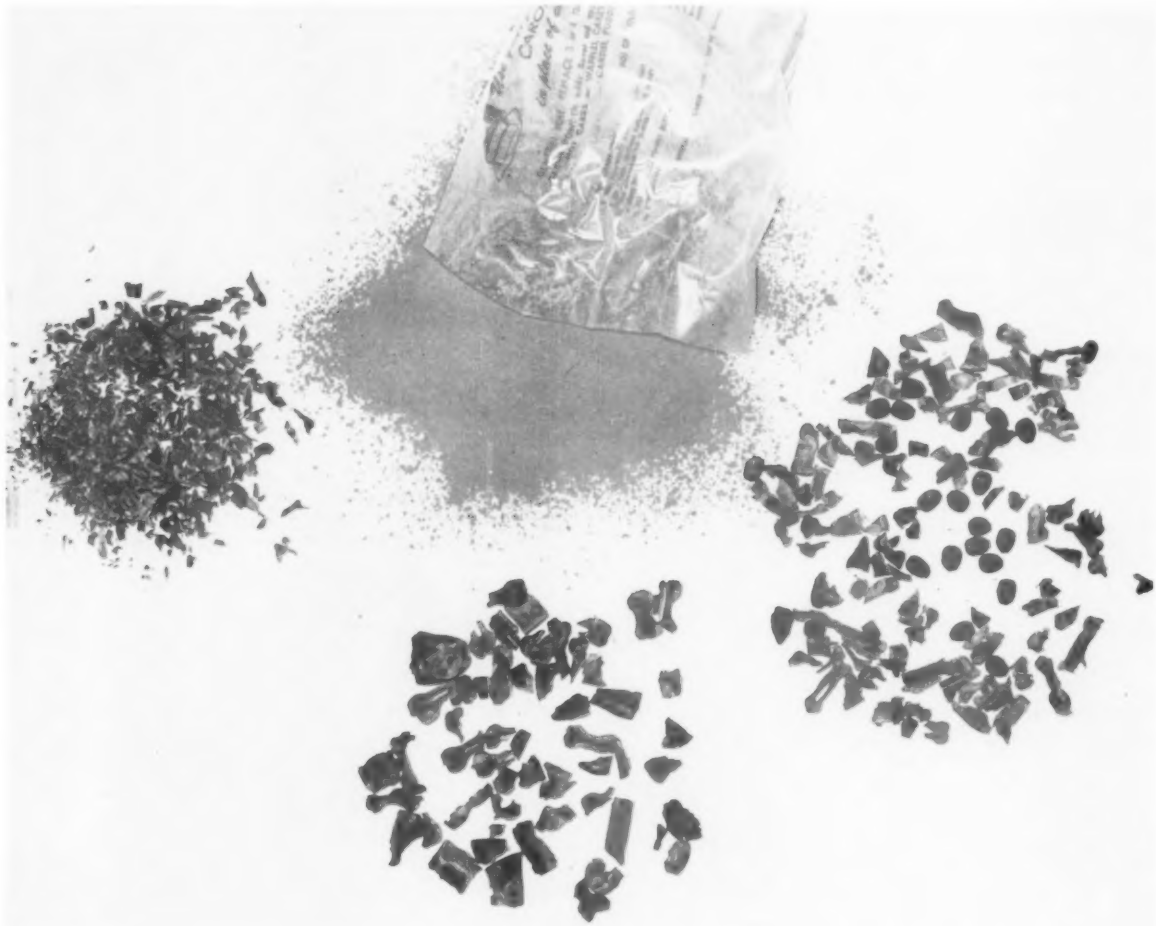

Figure 1. Commercially milled carob flour with three samples of kibbled carob pods. The seeds shown in the kibbled sample to the right of the flour are removed mechanically before the pod material is processed into flour.

recipes have been developed by commercial producers for use in cakes, cookies, candy, ice cream and other products in which chocolate is ordinarily used. An acceptable beverage resembling malted milk has been produced by mixing the flour into milk. Improvement in the "solubility" characteristics of the flour is necessary to make it as convenient to prepare as instant cocoa.

Flinty brown seeds approximately the size and shape of watermelon seeds are found at intervals along the brown carob pod, which varies with variety 4 to 12 inches in length. The pods of carob varieties discussed later contained from 5 to 14% by weight of seeds. This agrees with data reported by Oddo, Algerino, and Ribon *(18)* for varieties grown in the Mediterranean basin and vicinity. The investigation of Pritzker and Jungkunz *(20)* showed carob seeds to contain water 10%, nitrogenous substance 9.9, ether extract 1.3, crude fiber according to Bellucci 5.3, mineral matter 2.46, a trace of sand, absence of starch, water extract 50, chloroform extract of the water extract 0.34, pectin 3.9, mucilaginous material 41, tannins 1.2, reducing substance (Fehling) 0.6, mineral matter in water extract 1.6, N-free water-insoluble matter 24.3%, and alkalinity 24 cc. N acid.

The endosperm of the seed is manufactured into a gum, mannogalactan, known to the trade as "tragasol." In manufacturing tragasol gum, the skins of the seeds are removed. The seeds are roasted, boiled in water, and the resulting liquor is filtered and evaporated. The dried gum is then packaged for distribution *(15)*. The gum is in growing demand as an additive to many manufactured food products—such as cheese spreads, ice cream, frozen malted milks, salad dressings, chocolate milk, mustard, desserts, pie fillings, sausages, bread, and French dressings. Industrially, tragasol is used in paper sizing, textile printing pastes and warp sizes, creaming and thickening agents for rubber latexes, lithograph and writing inks, ceramic plasticizers, and mucilages *(6, 9)*.

Importations of tragasol into the United States in 1956 were 15,093,156 pounds, valued at port of export at $3,843,074. The five-year total of imports of tragasol, up to and including 1956, were 58,437,666 pounds valued at $12,224,085 *(5)*. Carob pods, whole and kibbled, were also imported in the amount of 2,511,614 pounds during 1956.

The embryo of the seed is used in Europe in the form of a meal to boost the protein content of mixtures of poultry foods. Kratzer and Williams *(13)* in 1951 reported growth inhibition when meal milled from whole carob pods was fed to day-old chicks. No attempt was made to identify the inhibitor nor was it determined whether the seed or pod flesh was responsible. No such growth inhibition was noted by Woll and Voorhies *(21)* or Jaffa and Albro *(12)* during feeding experiments with calves, steers, and horses.

EXPERIMENTAL ORCHARDS IN SOUTHERN CALIFORNIA

The climate of southern California is very similar to that of Mediterranean countries where the carob tree thrives *(4, 11)*. Because of its drought resistance the carob tree is recommended for planting where water is not abundant. When planted 35 trees per acre as recommended *(4, 6)*, trees should begin to bear 5 years after budding under favorable dry farming conditions. The yield should increase steadily to 100 lbs. per tree by the 12th year and should average 250 lbs. per tree by the 25th year. The 8,750 lbs. yield by 35 trees per acre is much more than could be counted on from hay or barley under similar dry farming conditions *(6)*.

Present and potential water supplies for southern California are very limited. Rapid growth in population is diverting an increasing proportion of available water from agricultural to domestic and industrial uses. Extensive areas of excellent foothill soils, relatively free from severe frosts and with annual rainfall of 10 to 20 inches, are now used for pasture or dry farmed to grain and hay. Grain and hay farming require tillage, which sometimes results in serious erosion damage to the land. Culture of the carob tree could provide profit as well as a means of soil conservation on this type of land. Rixford, in Bailey's *The Standard Cyclopedia of Horticulture (4)*, suggests that carob may well be grown profitably in the mild climate of the Gulf States, and especially along the coastal regions of Texas and the southern parts of New Mexico and Arizona.

In order to demonstrate to land owners the opportunity and practicability of the commercial production of carob as a new U. S. industry and for increase in income from their non-irrigated lands, Dr. Walter Rittenhouse of San Diego has provided funds for a demonstration and variety test orchard to be operated for 30 years as a public service *(6)*. The orchard, located in San Diego County, California, was planted to seedling carob trees in 1949. They have been budded with 19 of the best old varieties introduced from European countries and 40 of the most promising seedlings so far found in California. Thirty varieties have come into bearing. The various horticultural requirements of this crop are being worked out for the information and benefit of prospective commercial planters. Bud-wood of the varieties best adapted to the climate is being distributed to nurserymen at no cost. From time to time, leaflets on variety adaptability and cultural operations are distributed free. The establishment of the variety test orchard by Dr. Rittenhouse is, as far as is known, the first intensive effort to determine carob varieties adaptable to commercial cultivation in the United States under orchard conditions.

ANALYSES OF CAROB PODS

To acquaint the food industry with some of the chemical and nutritional factors of carob, samples from 30 varieties in Dr. Rittenhouse's orchard were supplied to the Western Utilization Research and Development Division in Albany, California, for analysis. Samples were harvested from young trees, some bearing their first crop. In some cases a sample consisted of the complete harvest from one tree. Therefore, the problem of obtaining a representative sample for analysis was not a major one.

The intact pods were split lengthwise and the seeds removed. The pod halves were broken in a hand food grinder, mixed well, and sealed in screw-capped jars fitted with rubber gaskets. Crude fat determinations *(3)* were performed on triplicate two-gram samples obtained from each jar. Values of pH were determined on a sample slurried with ten times its weight of distilled water. Wide variation in the ten-to-one ratio was found to have little effect on these values. A final sample from each jar, comminuted in 80% alcohol, provided material for the remainder of the analysis, namely, total and reducing sugars *(3)*, total nitrogen *(3)*, crude fiber *(3)*, ash *(3)*, anhydrouronic acid *(16, 17)*, and total solids *(14)*.

The brown carob pod is harvested in the fall from September through the middle of November, depending on variety and seasonal growing conditions. Moisture content varies with climatic conditions at harvest from 5% to as much as 30% moisture. Generally, however, moisture varies between 10 and 15%. Based on 10% moisture, the pod flesh of the carob bean is extremely rich in sucrose and invert sugars, and with its 4 to 6% protein content, compares favorably with barley in

TABLE 1

Compositional analysis of carob varieties, pod flesh only, based on 10% moisture

Sample No.	Variety [1]	Total sugar [2]	Reducing sugar	Protein (N × 6.25)	Crude fat	Crude fiber	Pectin	Ash	pH
		%	%	%	%	%	%	%	
1	Excelsior	40.7	11.0	3.31	0.56	8.0	0.59	1.84	4.62
3	Sykea	45.5	14.2	5.19	0.99	6.5	1.50	1.99	5.05
4	White	44.0	16.9	5.13	0.67	5.9	1.42	2.13	4.93
5	Seedling [3]	41.0	14.4	5.00	0.46	7.5	1.54	2.19	4.51
6	Francisco	42.4	19.7	3.69	.....	8.0	1.24	1.78	.....
7	Diego	42.9	13.1	4.63	0.51	8.5	1.56	1.55	4.99
8	Gorduro	40.6	14.1	5.00	0.48	7.3	1.48	1.75	5.02
9	Castaludos	41.3	12.0	6.13	1.30	6.1	2.00	2.28	4.84
10	Domic Krupni	51.4	9.7	4.63	1.01	6.8	1.48	2.22	4.93
11	Feminello	44.6	12.1	5.00	0.61	6.9	1.98	2.37	4.98
12	Mockingbird	43.1	15.8	4.75	0.69	6.9	1.11	1.92	4.98
13	Mekia	42.9	7.1	4.88	.....	5.5	2.01	1.84	.....
14	Sipanski	41.9	7.3	4.06	0.90	5.4	1.49	1.82	4.82
15	Sobrante	41.5	14.3	4.50	.....	7.8	1.58	2.03	.....
16	Conejo	50.4	13.0	3.75	.....	7.2	1.35	1.75	.....
17	Dickerson	41.2	12.1	4.38	.....	7.9	.....	1.69	.....
18	Fornay	41.6	10.3	4.25	1.10	7.3	.....	1.86	5.17
19	Mathews	40.6	11.2	5.44	.....	7.4	.....	2.22	.....
20	Antonio	44.0	10.2	4.19	0.96	8.3	.....	2.00	5.27
21	Apex	43.1	14.0	3.81	0.84	7.2	.....	1.75	4.98
22	Molino	39.4	8.7	5.38	0.54	9.2	.....	1.83	5.00
23	Santa Fe	47.5	7.8	4.44	0.61	6.4	.....	1.77	4.92
24	SFAX	51.6	12.1	4.44	0.50	4.9	.....	1.74	4.88
25	Laguna	37.1	11.3	5.25	0.56	8.6	.....	1.98	5.05
26	Tylliria	47.4	13.6	4.50	.....	5.5	.....	1.98	.....
27	Casuda	49.7	14.5	4.44	0.68	5.3	.....	1.69	4.82
28	Fargo	39.7	9.9	4.44	.....	9.6	.....	2.22	.....
29	Domino	38.3	8.0	6.63	0.49	7.8	.....	2.38	4.88
30	Melrose	41.9	13.8	3.69	1.46	8.2	1.02	2.05	4.90
31	Bolser	42.3	16.5	3.38	0.88	7.1	0.95	1.92	4.90

[1] 1957 crop.
[2] Total sugar reported as glucose.
[3] Row 15, No. 7.

nutritional value *(4, 12)*. Table 1 shows the wide range in total sugar, invert sugar, and protein to be found in the carob varieties analyzed. SFAX, Domic Krupni, Conejo, Casuda, Santa Fe and Tylliria (Figure 2) contain highest amounts of sugar but fall short of Domino, Castaludes, Mathews, Molino, Laguna, and Sykea in protein content.

Blending of a highly proteinaceous variety with one containing large amounts of sugar could help to balance protein with carbohydrate. The result could be a product of higher nutritional worth than if a single variety were used. Since there are very few, if any, carob trees in the Mediterranean area systematically arranged into orchards and cultivated solely for quality pods for human consumption, carob flour presently manufactured in this country from imported pod flesh is likely to vary considerably in composition and flavor.

PRELIMINARY TESTS OF FLAVOR

A preliminary tasting at Western Regional Research Laboratory of the whole pods containing the greatest amount of sugar indicated that flavor preference is by no means directly related to an abundant sugar content. For example, Domic Krupni, ranking second highest in total sugars, was much less flavorful than Santa Fe or Tylliria, which contain somewhat less sugar; Molino, which ranks extremely low in total sugars, was a much more flavorful variety than Domic Krupni. Of those varieties which were tested, Santa Fe was rated highest. It has a sweet

Figure 2. Pods representing carob varieties richest in total sugars. The size, shape, and thickness of pod varies widely depending on variety.

nutty flavor, high sugar content, relatively low fiber content, and a medium amount of protein. Flavor is an important consideration, possibly more so than sugar content. Consequently, in order to maintain flavor, sugar, and protein levels, a blend of two or more varieties, analogous to the blending of coffee or cocoa beans, is well worth considering.

Processing research is under way to determine the most economical method of separating the flinty seeds from the pod flesh and to improve the solubility characteristics of carob flour as it is now milled in this country for human consumption.

SUMMARY

Thirty varieties of carob have been analyzed for some nutritive factors in an effort to acquaint the food industry with these factors and to provide a preliminary survey of varieties that might be suitable for commercial cultivation in the United States. The carob varieties analyzed contained extremely high amounts of sugar, mostly sucrose and invert sugars, compared to other fresh fruit tree crops in harvest-ripe condition. Protein and carbohydrate content of the pod flesh makes carob compare favorably with barley in nutritive value. Imported carob is currently manufactured in the United States into a flour for use as a food and in pharmaceuticals. When incorporated into confections such as cake, cookies, candy, and ice cream, the flour imparts a flavor closely resembling that of cocoa or chocolate.

Acknowledgment

The authors express thanks to Mr. Lynus V. Richards for his contribution in preparing the carob samples for chemical analyses.

LITERATURE CITED

1. Abella, P. U. Treatment of acute infantile diarrhea with carob flour (Arobon). *J. Pediat.*, **41**, 182–187 (1952).
2. Andrews, H. S. The use of carob flour in gastro-intestinal disturbances. *J. Kentucky Med. Assoc.*, **49**, 279–280 (1951).
3. AOAC *Official Methods of Analysis*, 8th ed., 1955.
4. Bailey, L. H. *Standard Cyclopedia of Horticulture*, I, 717–18, (1941), Macmillan Co., N. Y.
5. Contained in private correspondence from the Bureau of Census, Dept. of Commerce.
6. Coit, J. E. Carob or St. John's bread. *Econ. Bot.*, **5**, 82–96 (1951).
7. Craige, J. E., and Oliver, J. W. Combination of anti-diarrheal agents for dogs using carob flour as a vehicle. *Am. Vet. Med. Assoc. J.*, **128**, 252–4 (1956).
8. Devlin, L. P. Enteritis in industrial medicine—carob flour (Arobon) in therapy. *Indust. Med. and Surg.*, **23** (4) (1954).
9. Hefti, M. Locust bean gum in the food industry. *Am. Butter R.*, **11**, 12, Oct., 1949.
10. Hogg, J. E. St. John's breadfruit; ceratonia siliqua, known also as honey locust, algaroba and various other names. *Nature Mag.*, **33**, 568-72D (1940).
11. Honey, R. Carob tree in Southern Italy (Commerce Reports No. 202), P. 792-3 Ag 28) '18 U. S. Bureau of foreign and domestic commerce, Washington, D. C.
12. Jaffa, M. E., and Albro, F. W. Nutritive value of the carob bean. Calif. Agr. Expt. Station *Bull. 309*, 441–50 (1919).
13. Kratzer, F. H., and Williams, D. E. The value of ground carob in rations for chicks. *Poultry Sci.*, **30**, 148–50 (1951).
14. Makower, B., Chastain, S. M., and Nielsen, E. Moisture determination in dehydrated vegetables; vacuum oven method. *Ind. Eng. Chem.*, **38**, 725–31 (1946).
15. Mantell, C. L. The water-soluble gums—their botany, sources, and utilization. *Econ. Bot.*, **3**, 3 (1949).
16. McComb, E. A., and McCready, R. M. Extraction and determination of total pectic materials in fruits. *Anal. Chem.*, **24**, 1986–88 (1952).
17. McComb, E. A., and McCready, H. M. Colorimetric determination of pectic substances. *Anal. Chem.*, **24**, 1630–32 (1952).
18. Oddo, G., Algerino, A., and Ribon, E. Analysis of samples of carob from all the Mediterranean basin and vicinity. Control and modifications in analytical methods. Chem. Abstr. **30**, 6974 '36. *Ann. Chim. Applicata*, **26**, 3 (1936). III, Extraction of crystallized sugar.
19. Plowright, T. R. The use of carob flour (Arobon) in a controlled series of infant diarrhea. *J. Pediat.*, **39**, 16 (1951).
20. Pritzker, J., and Jungkunz, R. Commercial St. John's Bread meal. Chem. Abstr., **38**, 3416 ('44). *Mitt. Lebensm. Hyg.*, **34**, 102 (1943).
21. Woll, F. W., and Voorhies, E. C. Feeding dairy calves in California. Calif. Agr. Expt. Station *Bull. 271* (1919).

Continuous High Vacuum Drying Techniques*

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(Manuscript received June 16, 1958)

DURING WORLD WAR II, the Armed Forces stimulated a great deal of research and development in the field of high vacuum dehydration. Their efforts were centered on the attainment of better quality whole blood plasma and several critical food items in a dry form. Since World War II, experimentation has continued in the area of drying techniques and equipment construction with special emphasis on satisfying the growing consumer demand for better and less costly dehydrated foods and beverages.

Successes in this area are evidenced by increasing consumer acceptance of the "instant" products on the market today. As an example, the housewife is demanding, and getting, an improved instant coffee. This is due to the fact that most instant coffee processors are adding instantizers to their processing lines in an effort to get instant solubility. There is only one process that we know of, however, that will give one-step instant solubility. It is high vacuum continuous dehydration.

PROCESS DESCRIPTION

The Continuous Dehydrator is used for materials which are oxidation-heat sensitive, or that require cooling to prevent caramelization after the drying process. It has found acceptance in the drying of materials such as: coffee, orange juice, grapefruit juice, and citrus vitamin P. It is presently under development for other materials such as: tomato products, chemicals, pharmaceuticals, etc.

Figure 1 is a functional diagram of the Dehydrator. The material to be dried is first pumped into the feed pan. The feed roll is partially submerged in the liquid and its clearance is adjustable from a few thousandths of an inch to as much as ⅛ of an inch. The feed rate is automatically regulated by a weighing device attached to the feed pan which starts or stops the feed pump, depending on the liquid level. After the pan is filled, the feed roll is started, and its speed is adjustable in the same range and speed as the belt speed.

After applying the material to be dried to the belt, it is then exposed to the first zone of radiant heat. This zone is made up of 4 individual banks which are separately controlled. The function of the zone is to pre-condition the feed—that is, to concentrate and/or expand the layer, and raise its viscosity and adhesiveness.

Pre-conditioning must be performed gently in order not to cause dripping or tearing of the layer of feed material from the belt. It must be timed, however, so that the feed is set firm enough to withstand the high evaporation rate occurring on the heating drum. Under certain conditions, the heat input from the radiant heat is high at first, and tapers off towards the drum. Other conditions warrant reversing these procedures in this zone.

After leaving the pre-conditioning zone, the material immediately passes over and around the heating drum, the temperature of which is adjustable from about 140° to about 300° F. Approximately 80% of the total drying occurs on the drum.

After leaving the second drying zone, the material passes under the last zone of radiant heat. Up to this point, about 90–95% of the drying has taken place. The remaining 5–10% is removed in the last zone, and since it is usually the most difficult to remove, this last zone is the longest, has the most banks of heat, and requires close attention during the startup. After leaving this last zone, the dried product is immediately passed over the cooling drum which serves to remove heat from the product and also from the belt. Here, thermoplastic materials are solidified and oxidation sensitive materials are reduced in temperature before exposing to the atmosphere. After being cooled, the feed is doctored from the belt by an oscillating blade and discharged into a screw conveyor which empties into alternating receivers for final removal.

PROCESS VARIABLES

It will be noted in Figure 1 that the first bank of radiant heat is exposed towards the belt. Applying heat in this direction causes the heat to travel through the belt. Consequently, evaporation first occurs next to the belt. The formation of water vapor and dissolution of gases cause the layer to expand to a blistered or puffed layer. (Puffing was first described as blister drying, but soon gave way to the now popular name of puff drying.) This is illustrated by the light particles to the right in Figure 2 which is an actual photograph showing the first stages of drying orange juice.

The second stage of drying occuring on the heating drum is quite rapid because of the pre-conditioning which occurred during the first zone of drying. The blistering which occurs

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, May 28, 1958.

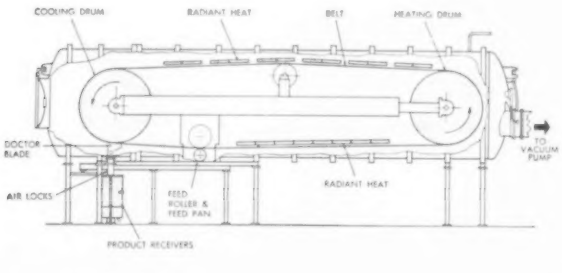

Figure 1. Functional diagram, high vacuum continuous dehydrator.

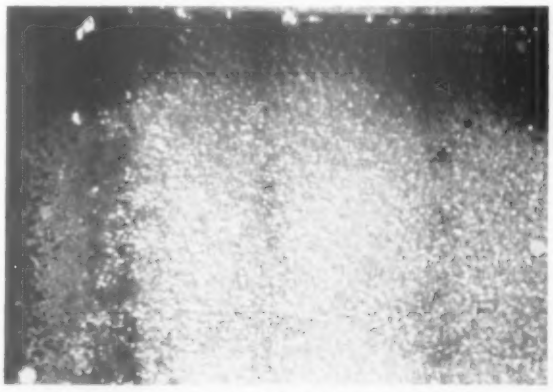

Figure 2. Orange juice dehydration, expanded layer.

during the first zone of radiant heat greatly increases the surface area for vapor escape during the second stage of drying. Since most of the drying occurrs on the heating drum, and the first stages of drying occur next to the belt, the remainder of the drying must be performed on the surface of the product.

Drying time or time of exposure can be adjusted over a wide range—from several seconds to several minutes. Approximate drying times are easily determined with the Milwaukee pilot plant facilities. However, these rates are generally too low and lead to conservative figures. Drying capacity ratio for the pilot plant is 1 to 12.5 compared to commercial equipment which report better ratios. These better drying rates can probably be attributed to better zone control during all stages of drying, particularly the first and third zones.

Final density is controlled by several factors, four of which are: aeration, deaeration, per cent total solids, and profile temperatures. Aeration is accomplished by feeding air or nitrogen or possibly carbon dioxide into the liquid feed. (Other gases may be used.) This procedure may be accomplished by using mixers, homogenizers or the like, and possibly by adding a solid chemical which will give off the desired gases on solution. The aeration step adds dissolved gas, and, if carried on further, it adds occluded gas. The intent of aeration is to produce an expanded layer on the belt during drying—a layer which would be thicker and less dense than a deaerated feed.

Aeration has been carried out on a laboratory scale using Milwaukee pilot facilities. It has been observed that batch shelf dehydrators must often have aerated feeds for successful dehydrating. Using the same feed material without aeration in the pilot plant equipment often produces products which are better than the controls made in the batch dryers. This has proved true in dehydrating tomato paste and tomato juice concentrate, and also in drying citrus products. Often, however, there are adequate water vapor bubbles formed in the feed layer during drying to create sufficient puff. There is no necessity then for aeration.

Deaeration is generally used with materials that have low viscosities compared to concentrated citrus and tomato juices. Typical examples where deaeration is required would be in the dehydration of coffee concentrate, tea concentrate, and berry juices. Deaeration is usually needed to reduce spattering and excessive flashing in the feed pan.

In general, as the percentage of total solids increases, the final density will also increase. However, even though the final bulk density may increase, flake characteristics may be such that the apparent bulk density would decrease. Several powders have these peculiarities, but they can be easily determined through pilot plant test work.

Once it has been determined whether a product must be aerated, or deaerated, or that a total solids adjustment must be made, the next control of importance is the profile temperatures of the radiant heat. In general, the materials which are high in sugar content, and thermoplastic to some extent, can be quite easily controlled by using the proper degree of radiant heat in the last step of drying. In other words, if density is too low, which would result in a light product, the radiant heat may be increased, in turn, to increase the bulk weight of the finished product. Some caution, however, must be exercised to prevent over-heating of the dried product.

EXTERNAL PLANT VARIABLES

Processing the feed before it reaches the dryer may not be too carefully controlled to insure a consistent product for dehydrating. If the feed is low in total solids, which would normally result in a product too light for packaging, several steps may be taken in the dehydrator to correct this error.

One step is to increase the heat profile slightly during the last stages of drying to produce a more dense powder. Another is to increase the chamber pressure, which would reduce the tendency of the material to puff on the belt. Then, too, the feed roll speed may be increased, which results in a thinner layer. Increasing the heat profile and the feed roll speed would tend to decrease the production rate of the equipment.

To maintain the same production rate, the cooling drum temperature would have to be dropped so that a heavier layer could be applied. However, the choice may be to increase the belt speed somewhat and, at the same time, lower the cooling drum temperature. These are steps which are best determined through actual experience with the product under consideration. If the product is too high in percentage of total solids, the reverse of the above procedures will give a less dense material.

FEED MATERIAL CHARACTERISTICS

For reasons of economy, feed material should be concentrated prior to drying. The extent of concentration is governed by cost factors, desired characteristics of the dried product, efficiency of drying, and ease of handling. Feed material that is too dilute may spatter or drip from the belt, or fail to expand to the desired structure.

There are three important characteristics of the feed material which influence drying. These are: per cent solids, per cent sugars, and the ratio of adhesiveness to density. An adhesive factor of about 0.05 g/cm^2 and a viscosity of 5,000 to 10,000 centipoise seems sufficient for good application.

Many products have a high viscosity, over 100,000 cps, and a low adhesiveness. Cottage cheese falls into this category and would present several problems in applying to the belt. Orange juice at 60° Brix has a sugar content of up to 75% on a dry weight basis. This material has a viscosity of 2,000 cps and an adhesiveness of 0.06 g/cm^2. It is ideal for applying to the belt.

Essentially, all of these factors must be taken into account in order to obtain a suitable product structure on the belt; a high production rate; and a particle of good volume, color, and solubility.

STARTING THE EQUIPMENT

Soon after the equipment is under vacuum, the drive motors are started and the various heating elements are turned on. Providing the equipment is turned on in proper sequence, the machinery will be up to operating temperature, and the chamber down to operating pressure at about the same time. If the feed must be deaerated, it is first heated to about 100 to 140° F. This range is dependent on the feed since it is critical for a specific product with a certain percentage of total solids.

The feed roll (having a predetermined clearance, about 0.012 in.) is started after sufficient feed has flowed into the feed pan. The material applied to the belt begins to dry immediately upon application; the belt is cooled and, at the same time, the adhesiveness at the interface increases. With increasing of adhesiveness, it is possible to increase the temperature and consequent drying rates. The adhesiveness and ex-

panded layer must be sufficient to prevent spattering from the heating drum. The drum temperature is increased until spattering starts, and then backed off just a bit.

The upper bank of radiant heat is increased until bubbling or boiling stops, just as the belt approaches the cooling drum. The cooling drum then serves to cool the belt and product as required. This completes the drying cycle.

COMMERCIAL ADAPTATIONS

The Continuous High Vacuum Dehydrator will dehydrate difficult-to-dry materials which are heat or oxidation-sensitive, and that exhibit some degree of plasticity during drying. The commercial installation shown in Figure 3 is a typical example of its use in this area. It produces citrus juice crystals *(1, 3)*. Equipment such as this is also being used to produce instant coffee. The first coffee machine of this type was installed in 1952.

Another example is found in the pilot vacuum dehydrator shown in Figure 4. It was recently installed in the Eastern Utilization Research and Development Division, USDA at Chestnut Hills, Philadelphia. It is being used principally for pilot plant studies on whole milk.

Figure 5 illustrates the volume and weight of crystals required to provide an 8-ounce glass of beverage. The individual serving for this size glass varies, depending on the size of the crystal and the bulk weight of the material. It also illustrates that there is a wide variety of bulk densities for packaging. In each case,

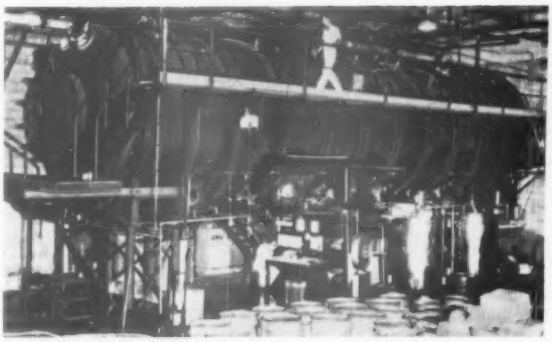

Figure 3. Commercial installation of a vacuum dehydrator.

Figure 4. Pilot plant vacuum dehydrator.

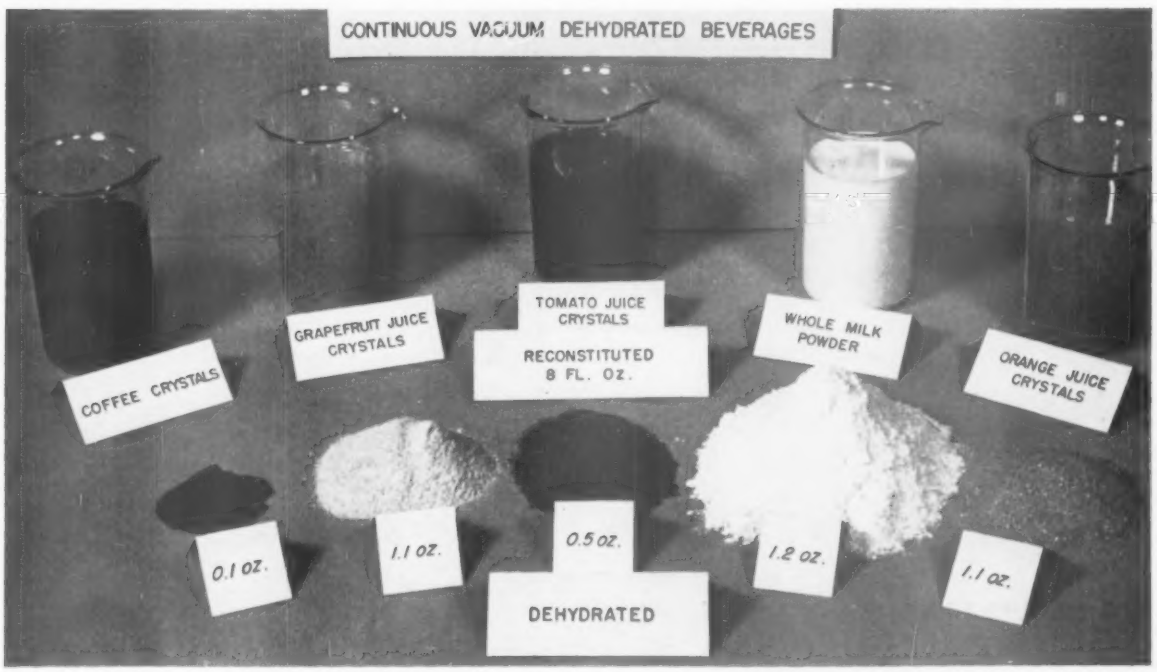

Figure 5. Comparative volume and weights to make an 8 fluid ounce drink.

the bulk density has been adjusted to convenient package sizes for dispensing the powder. In the case of orange juice, a one-pound can will make one gallon of single strength juice. One teaspoon of tea will make one glass of iced tea. This type of beverage preparation has met with considerable consumer acceptance within the last 10 years.

The Milwaukee pilot plant has done considerable drying of other products such as skim milk, malted milk, chocolate malted milk, various soft drink bases, tomato juice concentrate, and tomato paste concentrate *(2)*. Commercially feasible drying operations have been demonstrated by using tomato concentrate with 30–40% solids. To the present time, over a thousand pounds of tomato powder have been successfully produced. Some of this tomato powder is undergoing evaluation at the Quartermaster Food and Container Institute in Chicago. This product has been used as one of the components for the precooked dehydrated meals developed by the Institute.

LITERATURE CITED

1. Bonnell, J. M. Continuous vacuum dehydration of citrus juices. Florida Engineering Society Journal, 11 (4) (1957).
2. Continuous tomato juice drying tests successful. *Western Canner & Packer*, June, 1955.
3. Superior dehydrated juice. *Food Eng.*, March, 1955.

(Continued from page 16 preceding Technical Section)

Mr. Don Clerkson, Northern Farm Machinery Sales, thanked the speakers on behalf of the group. Coffee and cakes were provided under the auspices of Miss Martha Poolton of the Home Economics Department, U. B. C.

NORTHEAST

It was a genuine pleasure to again welcome Mr. Ray B. Wakefield, Director of Research and Quality Control of Gerber Products Company, Fremont, Michigan and President-elect of our national Institute of Food Technologists to our fourth meeting of the current season. Mr. Wakefield spoke on the subject, "Horizons on the Food Industry." Since this was "New Members Night," it was particularly fitting that Mr. Wakefield selected such an appropriate subject. Mr. Wakefield spoke on the influence of such factors as: population expansion, the standard of living, and the impact of war.

The Northeast Section of IFT takes justifiable pride in the fact that two students at the Food Technology Department of M. I. T. have been selected as winners of the Gerber Baby Foods Scholarships for 1958-1959. These awardees are Mr. Robert P. Bates and Mr. Norman Bednarcyk. Mr. Wakefield took the occasion to make suitable presentations to the winners.

S. CALIFORNIA

The outgoing chairman of SCIFTS, Mr. Gordon Beisel, head of Development, Sunkist Growers, Orange Products Division, was speaker at the January 21st meeting. His topic, "Quandary of the Food Technologist," was most inspirational and furnished much food for thought on the professional training requirements for a person to attain success in the food industry today. He adequately discussed such pertinent questions as: "Are today's food technology students being defrauded?," "What of the chemist, biologist or engineer who is currently working under the Food Technologist classification?," "How does he fare by comparison to his professional counterpart in other industries?" Mr. Beisel stressed the modern trend on the part of leading universities to alter the curriculum from "Food Technology" to "Food Science," omitting descriptive courses in Food Technology and introducing more of the humanities and, especially, advanced work in the basic sciences and mathematics. The graduate would then be above the trade school level and have the background needed for this technical field of the foods industry. Mr. Beisel emphasized that training in the art of communication through effective report writing and oral expression were essentials for a graduate food scientist.

—Howard J. Dunn

Industry

A. E. Staley Comments on Business Outlook

The over-all business outlook, states **A. E. Staley,** Chairman of the Board, A. E. Staley Manufacturing Co., is much brighter than it was only a year ago and in many respects the recovery was more spectacular than the recession. The old year turns out not to have been so bad after all, and business should benefit in the new year from recent experience and the nation's rising economic confidence.

The A. E. Staley Manufacturing Co. expects to participate in what appears to be a better level of business activity now emerging. Although the corn refining industry is more recession resistant than many activities and doesn't fluctuate readily with economic cycles, it is affected in some degree. Thus the prospective improvement in general business conditions should have a favorable and beneficial effect on our operations. Supplies of both corn and soybeans are abundant, with all-time record harvests during the past season of thes two principal raw materials of the Staley Company.

During 1958, the Company's corn division maintained volumes near those of the prior year and the net profit was somewhat improved. The Company's soybean division continues to share in record demand for meal, and has thus far succeeded in finding outlets for the tremendous production of soybean oil resulting. The net effect has been somewhat more favorable profit margins in this division during the early months of the current fiscal year.

Continuing growth of the nation's food industry, keeping pace with gains in both population and living standards, provides increasing markets for the Company's food and feed products. Renewed momentum in other lines offers improved potentials for the Company's non-food industrial products.

New Research Center Planned

Fairmont Foods Company has announced plans for a new Research and Development Laboratory to be constructed at Omaha, Nebr. Work on the one-story brick building will begin immediately and should be completed by April 1. **John A. Robins,** Fairmont president, said the new laboratory will provide the latest in research facilities and equipment for use in testing all of the company's present food lines for possible improvement and for the development of new products. The laboratory will serve the entire Fairmont system which includes plant and branch locations in 26 states.

The present research staff, reporting to **Dr. R. P. Joslin,** Director of Research and Development, includes Dr. Wm. D. Rutz, Laboratory Manager, Mr. Geo. F. Dickensheet, Project Leader; and additional non-technical staff. Mr. E. A. Smith, presently of the Fairmont Quality Control Group, and an additional professional dairy technologist will re-locate to the new research and development laboratory when it is completed.

Literature

BOOKS

COMMERCIAL FRUIT AND VEGETABLE PRODUCTS. 4th Edition, W. V. Cruess. McGraw-Hill Book Company, Inc., New York. 1958. 884 pages.

This book is the latest edition of a well-known, valuable textbook and reference source. It has been designed primarily as a college-level textbook and as such contains much general information rather than detailed discussions on particular areas. As the title suggests, the book is devoted to a discussion of commercial fruit and vegetable products. Commercial processors, especially fruit and vegetable canners, should also find in this book a great deal of information pertinent to their everyday operations. The author effectively combines practical process information with the technical conisiderations involved. At times, as in any general coverage of so wide an area of interest, the finer details of the subject are lost. However, each chapter is followed by detailed references for those who wish to investigate the subject further.

This book has been partially updated over the material presented in the previous edition. This newer material includes short discussions on the irradiation of foods, aseptic canning and high-temperature, short-time sterilization. Some of the major topics discussed are: tin and glass containers; treatment of fruits and vegetables prior to processing; processing of fruits and vegetables, including canning, freezing and dehydration and production of jams, jellies, etc.

This book is recommended as a college textbook and as a reference work for food processors dealing with fruit and vegetable products. Others in food and allied industries will find this book a valuable addition to their libraries.

CHARLES FELDBERG
Brooklyn, New York

LITERATURE ON FOOD RESEARCH AND TECHNOLOGY*

Food Technology

Methods and equipment for ice-packing poultry. Rex E. Childs and P. D. Rogers. Washington, U. S. Govt. Print. Off., 1958. 36 p. (U. S. Dept. of Agr. Marketing research report no. 242.)

Das Roggenmehl. Arne Schulerud. Detmold, Germany, Schäfer, 1957. 220 p. (Fortschritte d. getriedeforschung.) LW 19.60. Chemical and physical factors in flour for rye bread.

Chemical Aspects

Advances in carbohydrate chemistry, v. 13. Melville L. Wolfrom and R. Stuart Tipson, eds. New York, Academic Press, 1958. 399 p. $11.00.

Advances in enzymology and related subjects of biochemistry, v. 20. F. F. Nord, ed. New York, Interscience, 1958. 495 p. $12.50.

Die Methoden der Mikromassanalyse, 2nd ed. Josef Mika. Stuttgart, Enke, 1958. 375 p. brosch 63.00. Lw 66.00 DM. First edition in 1939 had title: Die exakten Methoden der Mikromassanalyse.

Scienza e alimentazione. A. L. Bacharach. Milan, Bompiana, 1957. 217 p. 700 It. Lire.

Bibliographies

Aviation medicine; an annotated bibliography, v. 2, 1953 literature. St. Paul 14, Minn., Aero Medical Association, 2642 University Ave., 1959. 354 p. processed. $5.00. Prepared in the Bibliography Section of the Library of Congress by Arnold J. Jacobus and others, and covers a number of aspects of aviation medicine in which food is important.

Bibliography of bacterial spores, Supplement no. 1. L. Leon Campbell, jr., Dorian Harris and Hilmer A. Frank. Pullman, Wash., 1959. 19 p. processed. (Washington. Agricultural Experiment Stations. Stations circular 323, Supp. no. 1.) pap. apply.

Bibliography of the nutritional aspects of the coconut. F. E. Peters. Nouméa, New Caledonia, 1956. 40 p. processed. (South Pacific Commission. Technical paper no. 95.) 2 s. sterling. A revision of a list first issued in 1954. The author is now at Purdue University.

Chemical compositions of South Pacific foods; an annotated bibliography. F. E. Peters. Nouméa, New Caledonia, 1957. 104 p. processed. (South Pacific Commission. Technical paper no. 100). 6 s. sterling. Author is now at Purdue University.

Miscellaneous

Les Comptes de la cuisinière, influence de la logistique sur l'art de la guerre. X. B. Leprince. Paris, Berger-Levraulte, 1958. 221 p. 900 Fr. fr.

Planning your research paper. F. B. Sanford. (Fishery Technological Lab., Seattle, Wash.). Fishery Leaflet No. 447, U. S. Dept. of Interior, Fish and Wildlife Service (April 1958); Comm. Fisheries Abstr. 11, 15 (Oct. 1958). This manual, which is divided into 2 main sections, presents suggestions on how to plan your research paper. The first section deals with preliminary steps in planning—such as outlining, choosing headings, and making tables. The second section deals with the various parts of the research paper: title, abstract, table of contents, introduction, acknowledgment, procedure, results and discussion, conclusions, summary, and literature cited. The difference between the conclusion and the summary is made clear, and the relationship between the title and the specific objectives listed in the introduction is pointed out. Finally, a way of avoiding repetition in writing the summary and the abstract is suggested.

Russian Materials

[*Automatic control in the manufacture of beet sugar.*] Automatizatsiia sveklosakharnogo proizvodstva. V. P. Mitrofanov and A. A. Rudzitskil. Moscow, Pishchepromizdat, 1958. 299 p.

[*Continuous mixing of pastry dough,* based on materials of the Central Design Office of the Main Machinery and Machine Parts Administration.] Nepreryvnyi zames testa dlia pecheniia rabota napisana po materialam TSentral'nogo konstruktorskogo biuro glavmashdetali. L. G. Dadykin, O. G. Lunin, and L. I. Tukarev. Moscow, Pishchepromizdat, 1957. 31 p. (Obmen peredovyn teknicheskim opytom.)

[*Initial processing of foods.*] Pervichnaia obrabotka i zagotovka produktov vprok. V. A. Sidorov. Moscow, Gos. izd-vo-torg. lit-ry. 1958. 150 p. (Biblioteka povara.)

[*Use of spent grain in yeast products; practices of the Kiev Yeast Factory.*] Ispol'zovanie bardianoi zolki v. drozhzhevogo proizvodstvel iz opyta Kievskogo drozhzhevogo zavoda. T. P. Vas'ko. Moscow, Pishchepromizdat, 1956. 22 p. (Obmen peredovym tekhicheskim opytom.)

[*Using antibiotics for the preservation of food products.*] Primenenie antibiotikov dlia konservirovaniia pishchevykh produktov. V. I. Kurko. Moscow, Vses. in-t nauchnoi i tekhn. informatsii, 1958. 34 p. (Pishchevaia promyshlennost'.)

* Material for this list should be sent to Dr. James G. Hodgson, Chief, Library Branch, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

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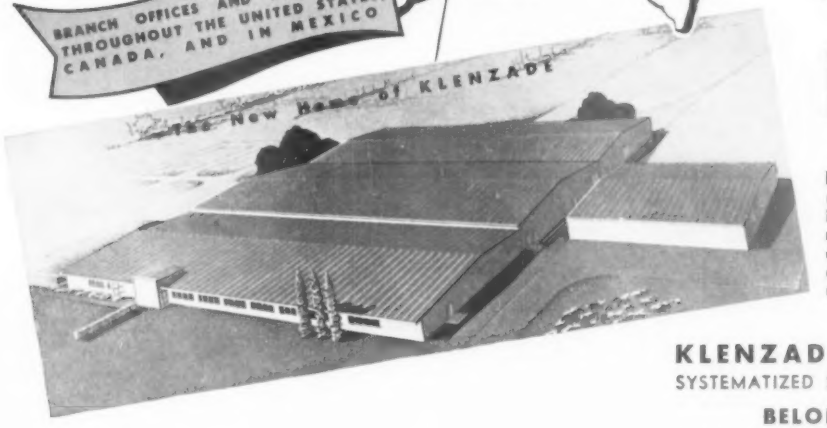

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ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

Units of measurements in gas chromatography.

JONES, W. L. AND KIESELBACH, R. (E. I. duPont de Nemours & Co., Wilmington, Del.). *Anal. Chem. 30*, 1590–2 (1958).

A revised set of units for use in the application of gas chromatography is proposed based on kinetics rather than equilibrium data. This gives more convenient recording and interpretation of results and facilitates quant. evaluation and control of the sepn. process.

Gas-liquid chromatography of highly unsaturated fatty acid methyl esters.

STOFFEL, W., INSULL, W. AND AHRENS, E. H. (The Rockefeller Inst., New York City). *Proc. Soc. Exptl. Biol. Med. 99*, 238–41 (1958).

Proof is presented that methyl esters of highly unsatd. long chain fatty acids are not significantly altered in chem. structure during gas-liquid chromatography with the stationary phase Apiezon M at 197°. A system for rapid total analysis of complex fatty acid mixts. on a submilligram scale is described.

A calorimeter for determination of heats of wetting.

GROSZEK, A. J. (Brit. Petroleum Co. Ltd., Middlesex, Engl.). *Nature 182*, 1152–3 (1958).

A suitable calorimeter was constructed to det. the heat evolved when solid surfaces come into contact with different amts. of liquids. The app. consists essentially of a cell filled with an adsorbent, thermocouples placed in direct contact with the adsorbent, and a suitable jacketing arrangement. The app. can det. heats of adsorption as low as 0.001 cal./g. and the time of each detn. is of the order of 30 min.

BIOLOGICAL SCIENCES

Biochemistry

Serum proteins in aged people. Electrophoretic separation of proteins.

ECKERSTROM, S. (Gothenburg, Sweden). *Geriatrics 13*, 744–6 (1958).

Electrophoretic sepn. of serum proteins is of great diognostic value in various pathol. conditions in aged people. They are known to be particularly sensitive to changes in food and liquid supply. Examinations of healthy people aged 70–80 years show serum protein values with the limits for healthy adults. In malnutrition, hypoproteinemia appears as a consequence of decreased serum albumin.

Coding problem in proteins.

SCHWARTZ, D. (Oak Ridge Natl. Lab., Oak Ridge, Tenn.). *Nature 181*, 769 (1958); *Chem. Abstr. 52*, 12028 h (1958).

A list is given of 12 amino-acid sequences involving a pair of aromatic amino acids as found in reports by other investigators. These sequences support the hypothesis that nucleic acid templates prescribe the positions of aromatic amino acids in proteins.

The inhibition of mitosis by the reaction of maleic hydrazide with sulfhydryl groups.

HUGHES, C. AND SPRAGG, S. P. (Natl. Vegetable Research Sta., Warwick, Engl.). *Biochem. J. 70*, 205–12 (1958).

The ratio of reduced (GSH) to oxidized (GSSG) glutathione, i.e. GSH: GSSG, in cotyledons was not affected by maleic hydrazide but at the onset of cell division GSH increased at the expense of GSSG in treated axes only. Certain enzymes requiring free sulfhydryl groups (starch phosphorylase and β-amylase) were inhibited irreversibly by maleic hydrazide, but other enzymes (trypsin and pea aldolase) were not affected. The results suggest that maleic hydrazide reacts with protein SH groups and thus inhibits the reduction of protein S-S by GSH during mitosis.

Studies on yeast invertase. III. Inhibition by Ag^+. Model experiments with egg albumin.

MYRBACK, K. (Univ. of Stockholm, Sweden. *Acta Chem. Scand. 12*, 839–50 (1958).

Experiments to support the view that Ag^+ is bound to egg albumin principally if not exclusively to HS-groups. The binding of Ag^+ by egg albumin is practically independent of pH in the pH-range mentioned, i.e. the HS-groups of egg albumin are, in contrast to those of invertase, freely available to Ag^+ in this range. In agreement with earlier investigations the number of HS-groups in an egg albumin molecule (M = 44,000) is found to be 5.

Distribution of D- and L-amino acids along the chain of poly-DL-alanine.

LINDERSTROM-LANG, K. (Carlsberg Lab., Copenhagen). *Acta Chem. Scand. 12*, 851–4 (1958).

The question concerning the distribution of D- and L-forms along the peptide poly-DL-alanine has been investigated by digestion with carboxypeptidase and aminopolypeptidase which preferably attack bonds between 2 L-amino acids. The analysis of the digestion curves makes it likely that the distribution of D- and L-forms is very nearly random in the particular prepn. under investigation.

Inhibition of dextransucrase by excess substrate.

NEELY, W. B. (Biochem. Research Labs., Dow Chem. Co., Midland, Mich.). *Nature 182*, 1007–8 (1958).

It has been noted by working with the polysaccharide-synthesizing enzyme, dextransucrase, that a plot of initial velocity v against substrate concn. deviated from linearity above a sucrose concn. of 200 mM. This phenomenon was examd. more closely using the conversion of sucrose to dextran in substrate concns. from 20 mM to 1,000 mM.

Microbiology

Preservation of cultures by drying on porcelain beads.

HUNT, G. A., GOUREVITCH, A. AND LEIN, J. (Research Div., Bristol Labs, Inc., Syracuse, N. Y.). *J. Bacteriol. 76*, 453–4 (1958).

Stock cultures have been preserved in the laboratory in several ways: agar slants under mineral oil, freeze drying, quick frozen suspensions in sterile milk. A new method of preservation on porous porcelain beads over anhydrous silica gel or calcium sulfate is described here. The method has the advantage of requiring little specialized equipment and results in a prepn. that can be sampled at different times.

Studies on factors affecting the rapid germination of spores of Clostridium botulinum.

TREADWELL, P. E., JANN, G. J. AND SALLE, A. J. (Dept. of Bacteriol., Univ. of California, Los Angeles). *J. Bacteriol. 76*, 549–56 (1958).

The germination of spores of *Clostridium botulinum* has been studied using changes in heat lability, refractive index, and staining properties as criteria for germination. Complete germination has been obtained within 2 hr. in 5% yeast ext., with outgrowth and multiplication in 4 hr. Complete germination has also been obtained in vitamin-free casamino acids. The necessity of sodium bicarbonate and the effect of heat activation on germination of this organism has again been demonstrated. It is suggested that the first step in germination is a change in the permeability of the spore coat, possibly mediated by a heat activated proteinase.

Nutrition

Effect of physical activity on increased coagulability of blood after ingestion of high-fat meal.

MCDONALD, G. A. AND FULLERTON, H. W. (Univ. of Aberdeen, Scotland). *Lancet 7047*, 600–1 (1958).

Any factor which operates over long periods and which can be shown to shorten the recalcified-plasma-clotting (R.P.C.) time is likely to be casually related to the development of atheroma.

The acceleration of the R.P.C. time after the ingestion of 85 g. fat was, to a large extent, abolished by moderate physical activity. The fasting R.P.C. time was shorter, and its reduction after 85 g. fat was greater in convalescent-ward patients than in "sedentary" patients.

Atherosclerosis in rhesus monkeys. I. Hypercholesteremia induced by dietary fat and cholesterol.

COX, G. E., TAYLOR, C. B., COX, L. G. AND COUNTS, M. A. *A.M.A. Arch. Pathol. 66*, 32–52 (1958); *J. Am. Med. Assoc. 168*, 969 (1958).

The authors present data on blood lipids obtained from 30 adult rhesus monkeys which were subjected to various fat-contg. diets for periods of several months to 3 years. The hypercholesteremic responses varied, some animals showing a "low" susceptibility to diet-induced hypercholesteremia and a moderate number showing either "moderate" or "high" susceptibility. These variations in response to dietary fat are comparable to the variations clinically observable in human subjects. The hypercholesteremia is interpreted as due chiefly to the excess of dietary neutral fat.

Beta lipoproteins and serum lipids.

Nutrition Revs. 16, 263–6 (1958).

Blood lipoproteins, as measured by paper electrophoresis, have a genuine significance in the pathogenesis of progressive atherosclerosis, the β-lipoprotein being characteristically elevated. In contrast, the majority of the values for cholesterol, phospholipid and cholesterol: phospholipid ratios were in the normal range. All lipoproteins and lipids showed characteristic sex differences and the average values decreased in the older age group.

Serum-cholesterol studies in Finland.

KEYS, A., KARVONEN, M. J. AND FIDANZA, F. (Univ. of Minnesota, Minneapolis). *Lancet 7039*, 175–8 (1958).

Statistics indicate unusually high mortality-rates and morbidity-rates in Finland as a whole, and in East Finland in particular, ascribed to coronary disease. The total cholesterol levels tended to be higher than those observed in populations elsewhere, and this excess was accounted for by β-lipoprotein cholesterol. In the age range 40–49 the men in occupations demanding heavy physical work had lower cholesterol levels than had the men in lighter work, but at other ages the cholesterol appeared to be unrelated to habitual physical activity. Smokers tended to have higher cholesterol levels and lower blood-pressures than had non-smokers.

Psychological aspects of obesity.

BRUCH, H. (Dept. of Pediatrics, Coll. of Physicians and Surgeons, Columbia Univ., N. Y.). *Borden's Rev. 19*, 57–73 (1958).

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A discussion of the psychological factors in obesity as they relate to the development of obesity, and the ways they are precipitated from the state of being obese and from misdirected efforts at reducing. The authors state that for a new perspective of the whole obesity problem, for a more objective, truly medical view, we must step outside the common cultural prejudices and look upon obesity and its various aspects as manifestations of special adaptive patterns intricately interwoven with a person's whole development and his life experiences. Obesity in spite of its many and obvious handicaps, has also a definite positive function. These positive aspects must be recognized before treatment with the prospect of lasting success can be carried out.

Formula diet for weight reduction.

Nutrition Revs. 16, 292–4 (1958).

A 900 calorie dextrose, corn oil and evaporated milk diet has proven a successful out-patient aid in weight reduction of obese patients. Of those who began treatment 53% lost over 20 lbs. Patient motivation remained the principal factor necessary for success. The work of others suggests that this diet may contain insufficient protein for health and that resulting anorexia may contribute to the success of the weight reduction.

Effects of an excess of a single essential amino acid.

Nutrition Revs. 16, 313–15 (1958).

Studies were conducted through 7 generations of rats in order to learn whether single amino acid addns. could affect the life span and reproduction of future generations. A standard diet was used to which 1% addns. of various racemic amino acids were added. The 1% racemic amino acid supplement had practically no effect on the growth of animals with the exception of lysine which resulted in retarded weight gain in the males in the first 4 to 8 weeks of the fourth generation. After 12 weeks this difference disappeared. This also happened in the case of leucine. Methionine and tryptophan appeared to improve longevity and increase resistance to infection. Lysine adversely affected longevity and resistance to infection. Valin had no effect on life span. Females fed with leucine could not reproduce after the 6th generation. Methionine and lysine resulted in a high percentage of sterile animals and lactation reduction. Tryptophan did not adversely affect reproduction.

Protein starvation and nucleic acids.

Nutrition Revs. 16, 304–5 (1958).

Protein nutrition (or at least some nutrient which is found in protein foods) is necessary for optimal synthesis of DNA and RNA on an intracellular basis as indicated by studies on sexually mature and immature rats. Whether the proteins (amino acids) are essential as direct precursors or whether the lack of protein interferes more indirectly with DNA and RNA synthesis within the cell must be investigated further.

Treatment and prevention of kwashiorkor.

Nutrition Revs. 16, 259–61 (1958).

Protein deficiency constitutes one of the most serious health problems of undeveloped nations. In trials conducted with children in West Africa the addn. of peanut press cake and peanut press cake plus fish flour have been found to be valuable protein sources for addn. to the basic millet or sorghum diet. Millet-peanut and millet-peanut-fish flour mixt. produced better wt. gains than skim milk. Workers under the auspices of the Institute of Nutrition of Central America and Panama have developed a vegetable mixt. now under study in general field trials. It includes 50% dried corn, 35% sesame meal, 9% cottonseed press cake, 3% torula yeast and 3% kikuyu leaf meal. The mixt. contains adequate proportions of most of the essential amino acids per g. of nitrogen. To date 11 children have received this mixt. with good results for a 100 day interval. The average retention was the same as that per equiv. wt. of milk protein.

Enzyme deficiency diseases. I. Galactosemia.

ZELLWEGER, H. U. (Dept. of Pediatrics, State Univ. of Iowa Hosp., Iowa City). *J. Am. Dietetic Assoc. 34*, 1041–3 (1958).

Galactosemia is a disease caused by an inborn error of metabolism. In humans galactose must be phosphorylated to galactose-1-phosphate to be absorbed. Galactose-1-phosphate cannot be utilized by the body unless it is converted into glucose. In galactosemia the enzyme galactose-1-phosphate-uridyl transferase is absent preventing the transfer of galactose-1-phosphate to glucose. Galactose-1-phosphate hence accumulates, particularly in the liver, causing cirrhosis, damaging the kidneys, intoxicating the whole organism leading to anorexia, vomiting, diarrhea and malnutrition. Brain damage also occurs either due to the glucose-1-phosphate or hypoglucosemia. The treatment for this disease is entirely dietetic and depends on the early institution of a galactose free diet.

Enzyme deficiency diseases. II. Phenylketonuria.

ZELLWEGER, H. U. (Dept. of Pediatrics, State Univ. of Iowa Hosp., Iowa City). *J. Am. Dietetic Assoc. 34*, 1045–9 (1958).

Phenylketonuria is a recessively inherited disease. Its cause is an error in the metabolism of phenylalanine to hydroxyphenylalanine or tyrosine due to the absence of the enzyme phenylalanine hydroxylase. Mental retardation is a predominant and nearly constant finding of this disease. Treatment of this disease is entirely dietetic and in 2 stages. The first stage is to bring the increased level of phenylalanine back to normal by the use of a phenylalanine-free or restricted diet. The second stage is aimed at maintaining a normal phenylalanine level by use of a more normal diet contg. phenylalanine at a level just high enough to prevent neg. N balance. This level varies from 15 to 40 mg./kg./day for infants to 3 year olds. Treatment of this disease must be instituted before 6 months of age to demonstrate improvement of intelligence and prevention of cerebral damage.

Special diets help some retarded children.

ANON. *Science Newsletter 74*, 265 (1958).

A special diet that eliminates phenylalanine, partially relieves conditions caused by the hereditary metabolic disease known as phenylketonuria. Other congenital metabolic diseases have also responded to dietary treatment. A report of work done in this area was presented at the International Nutrition Symposium at Pittsburgh, Penna.

Appetite stimulation in children.

Nutrition Revs. 16, 287–8 (1958).

An appraisal of the use of vitamins B_1 and B_{12} as supplements promoted for the stimulation of growth and appetite in children by the Committee on Nutrition of the American Academy of Pediatries has been made. The committee found no evidence that B_1 acts directly to increase appetite. No convincing evidence for growth promoting effects of vitamin B_{12} was found.

Sulfonylureas in diabetes mellitus.

SOBEL, G. W. AND LEVINE, R. (Dept. of Metabolic and Endocrine Research, Michael Reese Hosp., Chicago, Ill.). *J. Am. Dietetic Assoc. 34*, 1072–4 (1958).

Many thousands of diabetics are taking Orinase (tolbutamide) for the control of diabetes. The effective dose is 0.5 to 2.0 g./day. There appears to be no good reason to replace insulin with Orinase if insulin is doing an effective job, nor should this drug be given to those people who could be controlled by diet alone. These drugs are not substitutes for insulin but stimulate the release of endogenous insulin. Long range effects of Orinase intake and the mechanism of their reaction have not yet been detd.

Physiology

The regulation of thirst.

Nutrition Revs. 16, 302–4 (1958).

Studies performed with rats suggest that 2 centers within the hypothalamic region of the brain are partly responsible for the regulation of water intake. One of these areas when destroyed results in an abnormally large intake of water. Destruction of the other center results in

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the complete loss of thirst. It is further suggested that at least one portion of this area of the brain may exert its action through an hormonal substance, since an aq. ext. of the subcommissural area of the hypothalamus, when injected into rats, produced a marked reduction in their water consumption.

Toxicology

Heart lesions in mice caused by treatment with bishydroxycoumarin (Dicumarol).

DESSAU, F. I., KLEIN, S., LIPCHUCK, L., O'GRADY, J. AND TSALIKIS, J. (Research Div., Am. Cyanamid Co.). *J. Pharmacol. Exptl. Therapeutics 124*, 182–7 (1958).

Dicumarol added to either purified or pellet diets, at levels from 40 to 200 mg./kg. diet, induced heart muscle lesions in mice resembling those observed in mice kept on sulfaguanidine-supplemented purified diets. Vitamin E supplements to the diet did not modify the effect of Dicumarol (200 mg./kg.), while this effect was prevented by vitamin K_1 at 2 times, or Menadione at 8 times the dietary level of Dicumarol.

Effect of acetostearin on reproduction in albino rats.

AMBROSE, A. M., ROBBINS, D. J. AND DEEDS, F. (Western Utilization Research and Devel. Div., Albany, Calif.). *Food Research 23*, 550–3 (1958).

The data suggest that a diet contg. 10% acetostearin (AG-194) and having a vitamin E content normally adequate for satisfactory reproduction performance failed primarily because of increased vitamin E requirement and not because of a lack of essential fatty acids. Acetostearin raised the vitamin E requirement by facilitating its destruction. Antioxidant methylene blue had a beneficial effect.

Studies on absorption and metabolism of propylene glycol distearate.

LONG, C. L., DOMINGUES, F. J., STUDER, V., et al. (Research Center, General Foods Corp., Tarrytown, N. Y.). *Arch. Biochem. Biophys. 77*, 428–39 (1958).

The metabolism of propylene glycol distearate (PGDS) labeled with propylene glycol-1-C^{14} stearic acid has been investigated. *In vitro* hydrolysis of PGDS by steapsin has been demonstrated. The extent of absorption of PG*DS, PGDS*, PG plus S* are all similar to a C^{14} carboxyl-labeled stearic acid mixt. of glyceride esters. Continuous CO_2 measurements for 72 hrs. have been made for the above compds. and for PG* plus S. Results show that the propylene glycol stearate esters are hydrolyzed and absorbed in a manner similar to glyceride esters of stearic acid. The asterisk denotes the labeled portion of the molecule.

ENGINEERING RESEARCH

A statistical analysis of certain mixing problems.

KATZ, S. (Am. Cyanamid Co., New York City). *Chem. Eng. Sci. 9*, 61–8 (1958).

The problem of smoothing out concn. fluctuations by passage through cascades of stirred mixers is formulated from the point of view of probability. The formulation is in terms of the theory of random processes, and techniques based on covariance functions are introduced side by side with spectral techniques.

FOOD AND FOOD TECHNOLOGY

Cocoa and Cocoa Products

Sensible vs. latent heat removal in radiant cooling.

MILLS, C. A. (Univ. of Cincinnati, Ohio). *Intern. Chocolate Rev. 13*, 418–22 (1958).

The advantages of, and theory behind, radiant cooling for sensible and latent heat removal are discussed. Surface case-hardening while deeper layers are still liquid is avoided with radiant cooling, since the radiant change of state heat exits freely from the deeper portions as well as from the surface of the mass.

Flavors and Flavoring

Specific quantitative colorimetric method of analysis for citral in lemon oil.

STANLEY, W. L., LINDWALL, R. C. AND VANNIER, S. H. (Western Utilization Research and Devel. Div., Albany, Calif.). *J. Agr. Food Chem. 6*, 858–60 (1958).

The aldehyde, citral, is the component in lemon oil responsible for the typical lemon aroma. Methods of analysis used in the past for determining the citral content of lemon oils, however, were nonspecific and measured only total carbonyl content. A specific method for citral in the presence of other aldehydes and ketones has been developed. It is based on the discovery that citral with a reagent mixt. of vanillin and piperidine in abs. alc. forms an alc.-sol. green complex (absorption maximum 605 mμ). The method provides a highly sensitive and selective objective tool for evaluation and standardization of lemon oil quality and should be useful in following the effects of process variables and agronomic conditions on the compn. of lemon oils.

Gelatin

The mechanism of gelation. III. Phenomena of pregelation in gelatin solutions.

BOURGOIN, D. AND JOLY, M. (Inst. Pasteur, Paris). *Verhandlungsber. Kolloid-Ges. 18*, 36–46 (1958); *Chem. Abstr. 52*, 14825 e (1958).

The work is concerned with the viscometric study of pregelation. The viscosity [η] of gelatin solns. was measured systematically as a function of the velocity gradient, time of the sol-gel evolution, temp., and concn. The exptl. facts concerning the rheological properties of the solns. durng transformation are described. The change of log η is a linear function of time for each phase of pregelation, which fact permits the precise definition of the conversion rate of the solns. Particularly significant is the effect of the mech. treatment of the solns. on the rate of transformation.

Starch

Radiation chemistry of carbohydrates. I. Action of ionizing radiation on aqueous solutions of D-glucose.

PHILLIPS, G. O., MOODY, G. J. AND MATTOK, G. L. (Univ. Coll., Cardiff, Wales). *J. Chem. Soc.* 3522–39 (1958).

When irradiated in dil. aq. soln., D-glucose is degraded to D-glucuronic acid, D-gluconic acid, glyoxal, D-arabinose, D-erythrose, formaldehyde, saccharic acid, and 1:3-dihydroxyacetone, which have been estd. quantitatively. Hydrogen peroxide is also formed. The absorption spectrum of the irradiated solns. shows a characteristic absorption maximum at 265 mμ, sensitive to alkali; it is related to 1:3-dihydroxyacetone. By following the yield-dose curves for the main products, the primary and secondary products are distinguished. The main types of degradation are thus identified.

PHYSICAL CHEMISTRY

A new absolute molecular weight method for linear polymers.

BUECHE, F. AND HARDING, S. W. (Dept. of Physics, Univ. of Wyoming, Laramie). *J. Polymer Sci. 32*, 177–86 (1958).

The measured viscosity for concd. solns. of linear coiling polymers decreases with increasing rate of shear. By use of a theory previously derived to explain this phenomena, it is possible to det. the abs. mol. wt. of the polymer from measurements of this effect. The necessary data required for this detn. are readily obtained using a simple cone viscometer. Since the theory requires only a knowledge of the variation of viscosity with shear rate together with the polymer concn. and temp. to compute the mol. wt., the method is easily applied to any polymer of this general type. Since the method is only strictly valid for linear polymers, it appears that it may also be used in conjunction with other mol. wt. methods to obtain useful information concerning the extent of branching in the molecules.

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On certain peculiarities of the structure of fibrous proteins and polymers.

ANDREEVA, N. S. AND IVERONOVA, V. I. (Moscow State Univ.). *J. Polymer Sci. 31*, 257–62 (1958).

Analysis is made of the system of parallel chain molecules which has a long-range order in the arrangement of the structural units along the chains, and a short-range order in the packing of molecules. A soln. has been obtained of the problem of scattering X-rays on such a system. Analysis of the correspondence between theoretical results and the results for certain fibrous proteins and polymers has been made. This analysis shows that in some parts of these substances there are regions where the parallel chains are arranged without any correlation to the packing of the units of neighboring chains.

IN MEMORIAM

Dr. Elmer M. Nelson, Director, Division of Nutrition of the Food and Drug Administration, passed away unexpectedly at his home on December 24, 1958. A pioneer in vitamin research, his Government service began before its first commercial application required regulatory control. When the 1938 Food, Drug, and Cosmetic Act provided for added requirements for foods for special dietary use, Dr. Nelson was the chief authority for sound criteria to guide the Food and Drug Administration's proposals for regulations in the public interest.

E. M. Nelson

Dr. Nelson was widely known, not only for his long and effective service in the Food and Drug Administration, but also for his important contributions to the science of nutrition. He was a man eminently worthy of being remembered for his interest in the field of food technology. His scientific career paralled the exciting and dramatic developments in the field of nutrition since 1920. His activities in developing methods for vitamin assay in a period when there was little emphasis upon control must be regarded in retrospect as of great value to a growing industry. Improved methods encouraged further industrial research and made for an orderly and intelligent marketing of new products. His contributions to the food industry were recognized in 1949 when he received the American Grocery Manufacturers' Award. He was particularly honored in 1957 when the Babcock-Hart Award was presented to him by the Institute of Food Technologists.

Dr. Nelson acquired his graduate training at the University of Wisconsin, a student of Professors E. B. Hart and H. Steenbock. He took part in the studies that led to the discovery that vitamin D activity is imparted to foods by ultraviolet radiation. Dr. Nelson contributed also the knowledge of vitamin A—its characteristics and the biological means for its estimation. He was a pioneer in establishing international standards for vitamins.

Dr. Nelson brought to the enforcement of food and drug law, as it applied to nutrition, a firm but friendly attitude that gained the respect and confidence of the industry. Through straightforward discussion of mutual problems, he encouraged voluntary compliance. He sponsored and practiced this theme of education and mutual frank discussion of enforcement problems with representatives of the food and pharmaceutical industries throughout his career. In this association, he guided with integrity and knowledge the growth of research in nutrition.

With his strong sense of scientific honesty he abhorred the efforts of those who preyed upon consumers by exploiting new developments in nutrition science, to their own commercial benefit. Through his lectures, his participation in symposia, his writings, and testimony in many court contests, he was a leader in the campaign against nutrition quackery.

Dr. Nelson's membership and activity in scientific organizations indicate the regard in which he was held in the scientific community. He was active in the American Chemical Society, the American Association for the Advancement of Science, American Public Health Association, and the Society for Experimental Biology and Medicine, among others. He served for two terms as Associate Editor for the Journal of Nutrition, as Treasurer of the American Institute of Nutrition, and as its President in 1948.

The Commissioner of Food and Drugs, George P. Larrick, in commenting on the Administration's loss, said, "Dr. Nelson made significant contributions both in the broad field of public health and to the scientific stature of the Food and Drug Administration. He will be deeply missed as an inspirational leader and warm friend whose relationships with his associates were most harmonious. Our deepest sympathy goes to Mrs. Nelson and their children."

PERSONNEL

Dr. Walter A. Maclinn, formerly head of the Department of Food Science, Rutgers University, is getting oriented into his new post as Director of The Refrigeration Research Foundation, Colorado. TRRF sponsors a number of research projects at various education-institutions, and at other agencies, both of a fundamental and applied nature. The purpose of the research is to fill the gaps of knowledge that exist on how to maintain the high quality of perishable commodities under refrigerated and frozen holding conditions. One of the urgent problems in low-temperature preservation of foods relates to time-temperature tolerances. Dr. Maclinn considers that "one of the most vital questions for research to answer is: what is the ratio of high quality of frozen commodities to temperature deviations, integrated with duration of deviation?" Food freezing and refrigeration have affected a revolution in food harvesting and production, with many crops now substantially coordinated with the freezing and packing industry. The services of research

W. A. Maclinn

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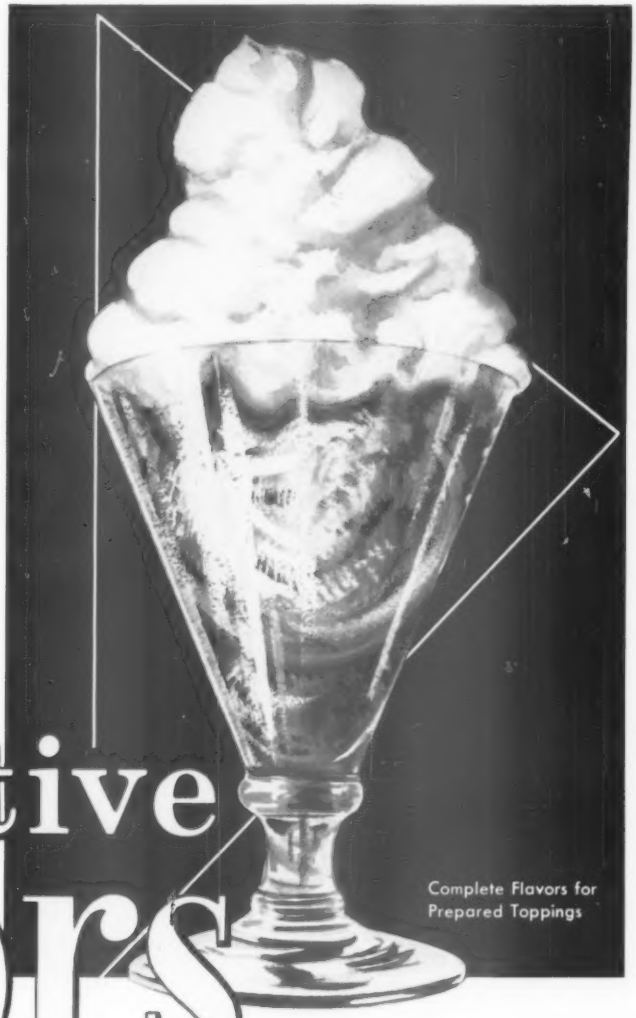

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J. M. Sharf

F. B. Menger, Director of Armstrong Research, has announced that **Dr. John M. Sharf,** Assistant General Manager of Glass and Closure Products Research, was promoted to General Manager, Glass and Closure Products Research of the Armstrong Cork Company, Lancaster, Pennsylvania.

Armstrong's Glass and Closure Division serves the food, beer and carbonated beverage, drug and pharmaceutical, wine and liquor, toiletry and cosmetics, and chemical, household and industrial markets with a wide range of glass and plastic containers and metal, plastic and cork closures.

Eric Vles

Eric Vles, Treasurer and Sales Manager of Polak's Frutal Works, Inc., Middletown, New York, was honored on December 16th on the completion of his 40th year with the company. The anniversary was celebrated at a dinner given for Mr. Vles at the Orange County Golf Club during the company's annual Sales Meeting. The firm presented him with a custom-made Hi-Fi Radio-Phonograph set. Mr. Vles began his career with P.F.W. in Amersfoort, Holland, in 1918 as a salesman. The first 10 years he traveled extensively on the European Continent. In 1928, he was transferred to New York where the company maintained an office and warehouse. Since then the company has steadily expanded and since 1950 has been located in Middletown, New York, where large manufacturing facilities are maintained. Mr. Vles will continue to occupy himself primarily with management of sales in North America.

Promotion of **Elmer M. Tomlinson** to civil engineer was announced by the A. E. Staley Manufacturing Co. of Decatur, corn and soybean processors. A. W. Neureuther, chief engineer, said Tomlinson will supervise the civil engineering section of the engineering department. Tomlinson, a 1932 graduate of the Missouri School of Mines, Rolla, Mo., has been with Staley's for 13 years. Before joining the company he worked for the Sangamon County Highway Department, the U. S. Corps of Engineers and the Illinois State Highway Department as a civil engineer on design and construction.

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Mr. Irving Fitzpatrick, President of Knickerbocker Mills Company, New York's century-old spice house, has recently announced the appointment of **Mr. Hans H. Welcker** as Sales Service Coordinator for that company. Mr. Welcker comes to Knickerbocker Mills with thirty-eight years of experience in the baking industry. Practical production experience was gained as

EXPANSION NEWS

GIVAUDAN FLAVORS, INC., ADDS NEW LABORATORIES

Givaudan Flavors, Inc. are well established in their new executive and sales offices plus laboratories and kitchen at 321 West 44th Street, New York City. Shown here are two members of the flavor laboratory staff working together in creating a new flavor. Formulation ingredients are checked in standard reference books, weighed on the new electronic scales, and recorded in the chemist's work book. Givaudan Flavors, Inc. also have a new, well equipped aerosol laboratory.

Production Manager of the H. Piper Baking Company in Chicago, sales and service experience with Hackmeister, Inc. in Pittsburgh, and promotional and service work with the California Raisin Advisory Board.

Dr. Kurt S. Konigsbacher is the newly appointed Associate Development Manager at Evans Research and Development Corporation, according to an announcement by Dr. Everett G. McDonough, Executive Vice-President of this New York City independent chemical consulting laboratory. In this new position, Dr. Konigsbacher will take charge of the expanding activities of the Home Economics Section, the Pilot Consumer Panel and the Trained Sensory Panel at Evans Research.

Dr. Joseph W. E. Harrisson, Director of La Wall & Harrisson Research Laboratories, Philadelphia (left) is shown as he was presented with the Honor Scroll of the Penna. Chapter, American Institute of Chemists by Dr. Emil Ott, the institute's national president. The Scroll is presented annually for outstanding contributions to science and the profession.

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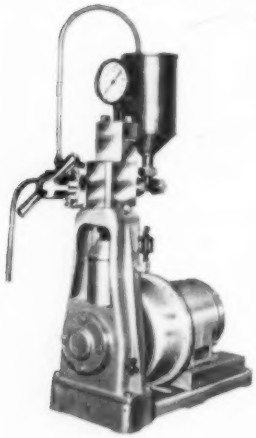
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Report No. 19 of a Series by Reynolds Metals Company

An early report, No. 6 of this series, presented the advantages of aluminum foil as a light barrier particularly in regard to prevention of oxidative rancidity in products containing oil or fat. Numerous experiments were cited showing the catalytic effect of light as a major contributor to this common form of food deterioration. Report No. 14 dealt with the effects of light on vitamins in enriched, partially baked rolls.

Milk—a Dramatic Example

Of the great number of food products affected adversely by light, however, milk is perhaps the most dramatic example.* Light acts upon milk principally in the following ways: (1) by catalyzing the oxidation of ascorbic acid, (2) by causing the destruction of Riboflavin and Vitamin A, and (3) by stimulating the development of oxidized and activated flavors.

A series of tests conducted for Reynolds Metals Company by the Wisconsin Alumni Research Foundation compared various types of milk in four types of containers: clear glass, brown glass, waxed carton and aluminum foil carton. The milk thus packaged was exposed to both fluorescent light and sunlight. The fluorescent lighting was designed to simulate conditions in a supermarket —the product being placed in an open top refrigerated display case maintained at 50° F., with the lights developing an intensity of about 100 foot candles. Tests under fluorescent light were made prior to exposure, then after 3 and 10 days. Those using sunlight were made prior to exposure, then after 30 and 120 minutes.

Summary of Test Results

Summarizing the separate tests measuring vitamin content before and after the indicated light exposures, the results were as follows. For Riboflavin (Vitamin B_2), no losses of nutritional significance under fluorescent light, but substantial losses in sunlight for milk stored in clear glass and waxed cartons — aluminum foil and brown glass affording excellent protection. For reduced Ascorbic Acid (Vitamin C), much slower rate of loss for milk stored in aluminum foil and brown glass —the pattern appearing similar in fluorescent and sunlight. For Vitamin A, only the milk in clear glass containers showed losses under fluorescent light; in sunlight these losses were very rapid and there was also some loss in waxed cartons.

Tests for Flavor Scores

Tests for flavor scores produced findings of special interest, since there appears to be a correlation between the formation of oxidized and hay-like flavors in milk and the loss of Ascorbic Acid. In the Table shown here, all scores of 35 or under represent a flavor defect — a definite oxidized flavor in whole milk and a pronounced hay-like flavor in skim milk. Here even brown glass failed to retard materially the flavor change. Only the aluminum foil carton proved effective under fluorescent light. And the results in direct sunlight were almost identical.

Manufacturers concerned with vitamin retention, or with other effects of light, such as oxidative rancidity, are invited to call the nearest Reynolds sales office. Or write to **Reynolds Metals Company**, Richmond 18, Virginia.

*Remainder of this report summarizes findings by the Wisconsin Alumni Research Foundation, as set forth in an article entitled "The Effects of Light on Homogenized Whole Milk and Some Fortified Milk Products", by J. J. Birdsall, L. J. Teply, P. H. Derse, in *Food Technology*, Dec., 1958, Vol. 12, No. 12, Page 670.

FLAVOR SCORES OF FOUR TYPES OF MILK STORED UNDER FLUORESCENT LIGHTS AT 50° F.

Package	Homogenized Whole Milk			Vitamin and Mineral Fortified Whole Milk			Vitamins A and D Fortified Skim Milk			Multivitamin Fortified Skim Milk		
	0 days	3 days	10 days	0 days	3 days	10 days	0 days	3 days	10 days	0 days	3 days	10 days
Clear Glass	39	33	33	38.5	33	33	38.5	33	33	38.5	37	33
Brown Glass	39	34.5	34	38.5	37	34	38.5	34	33	38.5	37.5	33
Waxed Paper Carton	39	35	34	38.5	33	33	38.5	36	33	38.5	37	33
Foil Laminated Carton	39	38	38	38.5	38	38	38.5	38	37	38.5	37	37.5

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